COSMOS

AND

DIACOSMOS

The Processes of Nature

Psychologically Treated

BY

DENTON J. SNIDER

ST. LOUIS, MO.,
SIGMA PUBLISHING CO.,
210 Pine St.
(For Sale by A. C. M'Clurg & Co., Booksellers, Chicago,
To whom the trade is referred.)

NIXON-JONES PTG. CO., 215 PINE ST., ST. LOUIS.

CONTENTS.

COSMOS AND DIACOSMOS.

INTRODUCTION.

The word *Cosmos* is sufficiently familiar to the reader in its general sense; but what about that other strange vocable in the above head-line, *Diacosmos*? Not known to the English dictionary, it has belonged hitherto to the Greek lexicon, in which it is ascribed to an ancient philosopher who maintained the atomic theory of the physical universe. More will be said upon this point and its significance later, when the atom in Natural Science comes up for consideration. At present we can merely give a forecast of the place and purport of the word in the following book. The prefix *dia* in Greek, whose ordinary meaning is *through*, or *asunder*, is derived from an old Aryan root, signifying *two*, and thus reaches back linguistically to the primordial con-

cept of division separation, twoness. In the ordering of Nature as here unfolded, the Diacosmos is taken to represent the entire second stage of the total process of Nature, that is, the separation stage, in contrast with the Cosmos proper, which is the first stage. To these two parts is added the third, and the three form the total cycle of Nature. The justification of these divisions must appear in the course of their special exposition.

I. There are and always have been various ways of looking at Nature and of formulating its activity in human speech. Primarily poetry seizes upon it and makes it the bearer of the soul's storm and sunshine, thus reproducing it as a symbol in one form or other. Different from poetry is the so-called poetic description of Nature. The art of Painting employs it in landscapes, often with a unique sympathy for its color. Nature is conceived to have moods and to show them in an ever-changing diversity, which starts corresponding echoes in the heart of man. The artistic use of Nature is properly a chapter in Aesthetics.

Philosophy also takes its early beginning from Nature. Ever memorable in many ways was the declaration of ancient Thales that water was the principle of all things, or the essence of being. He took a single physical object and conceived it to be the origin of all phenomena. Really he was seeking the unity of Nature, and tried to find in one

manifestation of it the source or ground of all the rest. The earlier Greek philosophers had the same general tendency, their aim was to philosophize Nature, hence they were called by Aristotle *physiologoi*, Nature philosophers. In them Philosophy and Natural Science had not yet been differentiated. In our modern time these two branches of knowledge have become not only distinct, but hostile. Significant is it to note that in the beginning the philosopher and the naturalist were one and the same, personally and scientifically. At the present moment it looks as if they were coming together again after their long alienation. Certainly recent physical science shows an emphatically speculative, theoretic trend, and is becoming in its way as idealistic as any philosophy. The atom, the ion, the electron, are ideas, supersensible forms, ever receding from the realm of the sensible; nor can they stop in this recession till they reach a universal principle. As the case stands at present, science is struggling to construct the supersensible out of the sensible, to make the universal out of something particular, and hence feels its own contradiction in every fibre. It resembles the early Greek philosophers who seized upon a special element and declared its universality, which was first a sensible material (as water and air), and then a supersensible material (the atom). This last is what modern physical science is unfolding to a supreme degree of refinement. Some of its devotees are trying to halt it,

but plainly it must go on till it completes its present phase of evolution.

II. Nature is a vast theme, indeed through it rises the very conception of vastness or magnitude; but vast as it is, we are to see it ultimately as only a part or phase of the great Totality, of the Universe as a whole. Religion, Philosophy, and Psychology also in the supreme sense grapple with this Universe each in its own way, and regard it as embracing the three grand divisions, usually called God, Nature, Man. These three form the process of the All which is psychical, or rather pampsychical, and which deserves a special name—we call it the Pampsychosis, or the psychosis of the All which is thus conceived as Self, having Nature as the second stage of its process.

Such a Universe cannot be interrogated concerning its origin from without, since that would contradict it in its essence. Cause does not apply to it unless it should be conceived as self-caused; if something else beside itself caused it, then it is not the Universe, which as Ego or Self must have its own process.

Nature, then, takes its fundamental character from the fact that it is the second or separative stage of the Psychosis, here of the All-psychosis. It is the derived, the created, the separated—from what? From the Primordial One as the creative Self, of which, however, we must grasp it as an inherent essential part. It is not to be conceived as

something ejected or externally formed by a transcendent creator, of whose perfection it constitutes no integral portion. To be sure, it is the stage of separation in and from the All-Self, and taking this point of view we may deem it the Unself of the Universe, the other side of the same and yet belonging to the same. Now this separation, very generally stated, is the most pervasive psychical characteristic of Nature, is what distinguishes it from beginning to end and unites all its varied phenomena in a common trait. And we are to see that this separation of Nature from the All makes Nature all-separative, cutting it up into ever-diminishing particles, atomizing it to the last degree of division.

To this basic originative conception of Nature we shall often come back to re-think it and to appropriate it anew. There is one, and only one, presupposition in the Universe, and that is the Universe itself, but as Self. It has no beyond or outside, for the beyond and outside lie in it. Still it as universal must be its opposite, its other, which as Plato long ago remarked, is Nature. Or we may penetrate to the thought in this way: the All-Self must unselve itself and through this act be complete as object; otherwise indeed its difference is outside of it and not a constitutive part of its process. Now this act of unselving itself and creating an Unself, gives Nature, the separative stage of the Universe. And furthermore, this separative act of Nature-making goes over into Nature itself,

which is perpetually self-reproductive in infinite diversity. And what we may call the first manifestation of Nature, Motion, shows the ever-separating character which is truly Nature's soul.

At this point another conception enters. Nature trying to get outside of itself in Motion, hints a striving for some end—what is that end? A kind of dissatisfaction it shows with its separation, and seeks to separate from the same, whereby it simply repeats the separative act. Still it keeps up the struggle to reach beyond itself, but cannot so long as it remains Nature. Gravity manifests the striving of an unobstructed stone to get rid of gravity at the center of the earth, or perchance at the center of the Universe. Nature in every throb reveals an aspiration to return to the All whence it came. But it must not, else that All would not be complete, would not have its total process, would not be All. Still Nature will whisper her ideal unity even in her real separation. In this aspect she, though the Unself, is always aspiring to re-selve herself in the fountain of her original existence.

III. From time immemorial men of thought have asked, What is the first of Nature? What object or appearance has the right to be considered primordial? In the multitude and complexity of natural phenomena, which one must be taken as the start of the physical world? Evidently that which actually starts in itself and is the pure form of all beginning—Motion. There is a remarkable con-

sensus upon this point; two of the deepest thinkers on Nature, Aristotle in antiquity and Descartes in the modern epoch, are agreed that Motion is the first of Nature and is wrought through the same from beginning to end under many shapes.

If we take a steady glance at Motion, we find it to be ever separating from itself and passing beyond; it is separation pure and simple, we shall call it the Separating in accord with its fundamental trait. It is the opposite of the All-Self, the most complete estrangement from universal selfhood; really the process of self-estranging it bears in its own bosom, so that it is always getting away from itself in order to be itself. Motion is, accordingly, the primal manifestation of Nature's dualism, its very birth-mark stamped at creation. The first antithesis of the All-Self is not Space, nor Matter (as some have thought), but Motion, which is the prototypal form of Nature, its all-separating act; for it is Motion which keeps Nature going, and radiates it out and beyond, toward infinity. Motion is the primal manifestation of the All-Self in its necessary self-opposition, that is, in its unselving itself and becoming Nature. Motion is accordingly the perennial decentering of all things and primarily of itself. Still it is a striving for the center, for the universal center, that is the center of the Universe—which remains a striving.

If Motion be the first, what is the second of Nature? Here again is quite a consensus of the best

judges, who select Matter. Motion and Matter are then the primordial twain of Nature sprung of the All. Sometimes the order is reversed into Matter and Motion, Matter being deemed Nature's first. Such an arrangement, however, obscures their physical genesis, and must be corrected.

Matter is, in its turn, the counterpart of Motion, being the fixed, the inert, the enemy of change. Still it manifests the full separation of Motion, only it does not move in itself; at least such is its appearance, even if modern Science is reading Motion into the molecules of rigid Matter. We have still to make a difference between Motion and Matter, between which exists a sort of perpetual war in Nature. How shall we distinguish them? Matter is as external as Motion, but halted in its externality and crystallized on the spot. It is not the separating, but the separated. It is already outside itself, not forever going that way, like Motion, but gone. It is not only external but self-external and thus space-occupying.

In its basic thought we shall call Matter the Separated of Nature in line with, yet in contrast to Motion as the Separating. With all their difference we shall find that they belong together in a common Psychosis which is hereafter to be developed. Accordingly we shall in the present exposition designate Motion and Matter as the Separating and the Separated, the active and the passive, both being derived from the All-self and opposites of it,

yet in diverse ways. Hence both are also opposites of each other, though in a single domain of Nature; they form a process together, in which a third element, Measure, will appear as their psychical correlative.

It may be added that Matter as separated from the great Totality will show its origin. Matter has gravity, which strives to carry all separated bodies into unity and thus overcome the separation involved in every material particle. Gravity may be deemed the soul of Matter, which longs to return out of its estrangement from the One-and-All. But this end remains ideal, an aspiration of Nature, which cannot be fully realized without breaking up the order of the Universe. The weight of a little piece of Matter is a voice which, when fully heard, speaks out of the heart of the universal Self.

IV. Nature is born with the original mighty contradiction between Motion and Matter, both of which rise through a series of forms or stages, with the ever-advancing triumph of Motion over Matter or of Force over Body, till Body vanishes and Motion remains as pure self-activity or self-movement in the human consciousness. This is no longer Nature, which must cease when its dualism between Motion and Matter ceases. Life is indeed a phase of self-movement, but is not purely such, being in a body which still gravitates. So the destiny of Motion (and with it of Nature) is to be its own Matter,

and to become self-moved within itself, in other words, to become the Ego.

As Nature is dual and indeed contradictory with its incessant play of attraction and repulsion, it was already in old Greece called dialectical. Matter and Motion are not only opposites, but each is internally self-opposed, contradicting itself. The well-known difficulty about Motion usually takes this form: a thing cannot move where it is and can not move where it is not, hence there is no Motion. The self-contradiction in Motion as the Separating goes back to Zeno the Eleatic. If Motion moves it quits itself, negates itself. And yet this self-transcending is just what Motion is. Deeper is the Dialectic of Motion as the separation from All-Self of which it still remains a part. Zeno also pointed out the Dialectic which is involved in the conception of Matter the separated; for if Matter be infinitely separated, it must be separated from itself—which is its negation. A similar Dialectic of Matter re-appears in Kant's second antinomy.

Without going into the details of this abtruse subject, we may mark the historic fact that an old Greek philosopher in the first half of the fifth century B. C., this Zeno, very distinctly affirmed the inherent dualism and contradiction of Nature, which was called its Dialectic. Particularly he singled out its first two manifestations, Motion and Matter, and showed their dualism, we might say

duplicity. There has been some question about the meaning of Zeno: did he intend to deny the sensuous reality of Motion and Matter, and so of all Nature? Hegel thinks that Zeno had no such intention, that he purposed to assert merely the untruth or the phenomenality of Motion and Matter. At any rate Zeno strikes the fundamental characteristic of all Nature as the second or separative stage of the Pampsychosis. He brings to the surface its twofoldness, its dualism. He, therefore, occupies a very important place in the history of the Science of Nature. It may be that he did not go so far as to deny the existence of an external world, though he showed its inner self-assailing Dialectic as a necessary element of its being. This external world, too, must be, even in its inner contradiction.

It should be added that the doctrine of Zeno has its application to Mind as well as to Nature. All finitude, be it inner or outer, is inherently dialectical, self-undoing, negative to itself. Zeno did not probably carry out his view so far, but it was much extended by Plato, though its fullest and most sympathetic elaboration is to be found running through the entire philosophy of Hegel, often called the last philosopher of Europe. Zeno's greatness is, as we look at it, to have given the first conception of a Science of Nature by showing its innermost character. To be sure his method was not that of the scientist, not experimental. He thought

Nature in its genesis, he re-created it in idea after its creator, and formulated the same for the future.

The dualism of Nature may be further illustrated by the doubt which it has often excited in speculative minds (doubt is itself dual, from *duo*). Is it an appearance to the senses without substance? Does it at times dart into reality and then flit out of it like a ghost, playing hide-and-seek with its pursuers, though they be scientists? We have already noted the present speculative tendency of Science, its flights to the supersensible. Famous philosophers have questioned the reality of Space and Time, others have reached the point of denying Nature on account of its Dialectic. Fichte questions it, Berkeley more than questions it. But because Nature is dialectical, gives no ground for denying its existence.

Here we may repeat that Nature, just through its separation and contradiction has its place in the Universe as pampsychical. There would be no Universe, no complete process of it, without Nature as its second or separative stage. This separative dialectical character of Nature is, therefore, fundamental, truly a necessary constituent of the All. It must be recognized at the start; the first duty of Science is such recognition. Philosophy and Theology have sometimes damned Nature as the evil one who is somehow to be put out of the Universe. Thus, however, they would completely undo themselves, and the Creator, too.

V. That Nature taken by itself is dual, has been stated sufficiently; but now we must add that her process, her movement is threefold, being at bottom psychical and therein bearing the impression of its origin. Nature we have seen to be a stage, the second, in the process of the universal Self, which process is psychical also. We must, therefore, put together these two thoughts: Nature is dual, but the process of this dualism is triple, that is, has its three stages. Or we may say that the content of Nature is the threefold process of her twofoldness. For instance Motion, Matter and Magnitude (Measure) form one of Nature's processes, to be shown later; but all three have in them Nature's primordial dualism, each in its own way. Inertia, Repulsion, Attraction, are three well-known categories of Matter, and make a psychical process together, but each is endowed with the original separative character of Nature.

All this is an illustration of a fundamental fact in universal Psychology: each stage of a psychical process must have in it that process in order to be a stage of the same. Or each part of a whole must have in it the process of that whole in order to be such a part. So Nature is a stage or part of the great Totality, of the Pampsychosis, whose psychical process must hold of Nature in order to make it a part or stage of the same. From this point of view we have again to observe the double character of Nature: It is on the one hand a single stage yet

also the total psychical process, dual in itself, yet triple in its movement, a part which must reflect the whole of which it is a part. On these lines we are to follow Nature unfolding as a link in the universal science of Psychology.

We have, accordingly, to see and indeed to feel in Nature a suggestion of something before it and beyond it, something from which it came and to which it is going. It is intermediate and in its way mediational; we may deem it the bridge between the absolute Self and Man, between the Pampsychosis and the Psychosis. Such intimations Nature has not only for the poet and seer, but also for the true scientist, and especially for the true psychologist. Nature's process is that of the Psyche, though it, taken by itself, is dual and separative. In the Ego the psychical process is what it is of itself, but not so in Nature, which, being in a state of separation and estrangement, strives to get out of it and to return. But this remains a mere striving, an end (the Aristotelian *telos*), which can be realized only by transcending Nature. Still this striving or ideal end of Nature is what organizes it and gives to it unity in its multitudinous shapes. Gravitation, for instance, which threads the whole Cosmos to its farthest reach, manifests the striving for the unification of all Matter. In the realm of life evolution reveals the grand striving of Nature for the highest organic form. Nature has her joys even in exuberance; a great philosopher, not a poet by

any means, could call her "a Bacchic god" in a mighty carousal of shapes, as if the Absolute were breaking loose through her into a fit of universal revelry. But deeper than her maddest delights is her soul's sigh for restoration out of her estrangement in the Universe. Such is the perennial undertone of Nature's aspiration, not to be neglected by the scientist. Schelling called Nature "a petrified intelligence," but the expression does not recognize her soulful striving underneath all her riotous play of forms.

The scientist is usually content to investigate Nature as it is in itself, in its dualism. He reduces its seeming license and lawlessness to law—certainly a great service. Thus he becomes the legislator of Nature, which cannot be allowed to run at will through the Universe. But the laws themselves become manifold and even contradictory; they too must be brought into an order which goes back to their source and puts them into an organic totality or law of laws. That brings us again to the psychical fountain-head of Nature itself, as well as of its laws, which will be found to be some part of its process.

Accordingly all the laws of Nature, so far as discovered, must ultimately find their place in some stage of the psychical process which runs through and co-ordinates the physical universe. Nature as a whole we conceive to be the absolutely separated from the All, and hence separated from itself, for it

belongs to the All. Here we may note again the flash of its Dialectic. Its character is, therefore, self-dividing, atomic to infinity, yet the atom, if material, is still divisible. Motion we may regard as the active atomizing of Nature, its Separating from itself, while Matter is the atomized, the Separated, the divisibility of Nature.

VI. And now we have to summon before us the total domain of Nature, and behold its full sweep from beginning to end. This would embrace the cycle of the Natural Sciences, each of which has its own special field, and is specially cultivated in our age of specialization. The attempt here is to see them not so much in their isolation as in their continuity and in their order, which is their process. Three grand divisions or stages constitute the totality of Nature from the foregoing point of view:

(I.) The first division we shall call the Cosmos, which term has been also used to designate the ordered Whole of Nature. The Cosmos as here regarded is the getting and the unifying of the physical universe, in its immediate separation from the All-Self, and it includes the first Motion and Matter, as well as their final organization into a system. But the pivotal characteristic of the Cosmos is Gravitation; all the separated bodies, terrestrial and celestial, draw one another in the smallest particle as well as in the largest mass, and so have the tendency to become one and form a unity.

(II.) Our second division is called the DIACOSMOS, of which word the general meaning has been already given. It is in its sphere the opposite of the Cosmos; instead of gravitating, it has the tendency to degravitate, to separate from body and to ray out in opposition to Gravitation. Light may be taken as an instance. Evidently this is the second or separative stage of Nature, which is itself the primordial separation from the All-Self in Motion and Matter, both of which are at work in the Diacosmos, as well as in the Cosmos, though in different ways.

In the nomenclature of the science of today, the Diacosmos embraces chiefly Physics, including Chemistry at the end and something of Mechanics at the beginning. On the other hand the chief content of the Cosmos is the mechanical aspect of Nature and includes astronomy.

(III.) To the third division of Natural Science we shall give the name BIOCOSMOS, or the Science of Life (*Bios*) in its widest aspect. The living Body does not simply turn outwards in action (as if radiating itself like the Diacosmos), but it also turns back to itself as center (as if gravitating to Body like the Cosmos). It is thus Body as self-moving or self-active, going out and coming back within itself, self-repellent and self-attracting in one—a conjunction in its way of the two previous spheres of Nature. Science, however, has not yet bridged by actual experiment the chasm between the Diacosmos in its final form of Chemism and the Biocos-

mos in the earliest beginnings of life. The best scientific heads are in agreement that no chemical process has yet produced vital action. So we have to pass over this scientific chasm at present on the wings of thought (which wings the scientist often does not possess, and so is inclined to scoff at). Far more easy experimentally is the transition from the Cosmos to the Diacosmos; indeed they, though vast counterparts of Nature, often move along side of each other even in their opposition. For this and other reasons these first two divisions of total Nature bear to each other an intimate relation which they do not bear to the third. So they may well be put together in one book as a treatise on inanimate nature.

But animate Nature or the Biocosmos (literally the order of Life) is really not the second stage but the third, having the psychical principle of return out of separation. Moreover it is as yet limited experimentally to our planet, though some scientific inventor may bring to light a true bioscope which will reveal the life on distant spheres, as the spectroscope shows to our eyes the chemical elements of the sun and stars. And we may suppose that the existent break in the evolution of Nature as a whole, which seems at present to be narrowed down to the chemical on one side and the vital on the other, will be overcome through the thousands of patient investigators, and demonstrated by sensuous proof, which is the grand function of physical science.

So we put together the three Orders of Nature—the three Cosms we might call them in allusion to their common terminal word—Cosmos, Diacosmos, and Biocosmos. This is the psychical process which organizes Nature ultimately and shows its origin. It is not to be conceived as an accidental co-ordination of unrelated divisions, but as the very impress and movement of the universal Self (or Pampsychosis) in its supreme self-separating act. Thus while Nature is dualistic and separative, the organization of it is threefold, and this doubleness between its original character and its organizing principle will remain to the end, and make it truly Nature's Science, a Science on the one hand but on the other the Science of Nature.

A favorite expression of Liebig is said to have been: I think in phenomena. That is well as far as it goes, especially for the experimental scientist; but he would have been a completer man if he had thought also through and out of phenomena. Tyndall in response to some demand for his general theory of Nature replied: I have not even a theory of magnetism. The answer may have a touch of scientific bravado directed against the prying inquirer, for Tyndall in other passages shows a decided striving for the unity of Nature, and can even declare that it must ultimately reach up to a spiritual origin, though of this he has nothing further to say.

In his investigation of the fall of bodies Galileo pushed beyond Aristotle, but Newton pushed be-

yond Galileo with the law of universal gravitation, while modern science is seeking to push beyond Newton by discovering the cause of the mysterious *actio in distans.* For Gravitation is not separated by Space and Time, the primordial separators of the physical universe; it is not obstructed by Matter intervening, nor by any force crossing its path; verily it seems to share in the creative, universal Motion. With its net-work of connecting lines between the smallest particles and the largest masses throughout the remotest spaces it has the appearance of holding together the Cosmos and of keeping its original separation from becoming a forthright plunge into chaos.

It may be here observed that the three supreme Orders of Nature—Cosmos, Diacosmos, and Biocosmos—have three dominating names of scientists attached to them in three successive centuries. Newton's peculiar field was the Cosmos, which he scientifically unfolded and to which he gave its ruling category—Gravitation. If Newton belongs specially to the mechanical 17th century, Dalton is of the chemical 18th century, with his prevailing atomic theory, even if he too (like Newton) reaches beyond his century in years. Darwin makes the 19th century the great biological era of science with his doctrine of evolution. The fact is significant that Dalton is no such towering figure as Newton or Darwin; he is of himself somewhat atomic in comparison and shares his honors with many other

atoms who are quite his equals. Still it is Dalton who has pre-eminently given to modern chemistry and physics the fundamental category of atomism, though suggested in Greek antiquity by Democritus and others. Looking into these three terms—Gravitation, Atomism, Evolution—all of them expressive of theoretic views of Nature, we may see a common element in them, indeed a process which unites them all in an underlying bond which deeply conjoins three centuries of science.

The question cannot fail at this point: What is the coming century to give us in the scientific field? Is it also to concentrate itself in a single lofty peak rising above all the other mountains though these be high too? Are we again to have some new dominant theory in some department of Nature which speculatively takes hold of the age like Darwinism? Prophecy is perilous especially in science, and indeed is considered unscientific. But we may at least note the call, somewhat loud, for the correlation and synthesis of what has been piled up in such vast detail. The scientist of course is primarily to do this, when one great enough appears. Still we may be permitted to note the time's eager search for the unifying process of the three leading stages of Nature, which can be designated as its three Orders or Kingdoms, or perchance Cosms. The principle of unity must be found in each of them separately and in all of them together, otherwise there is no true unity.

In its psychological aspect Nature is conceived as an act of Will; hence the study of Nature has a tendency to emphasize volition as the fundamental principle of the Universe. So it comes that not a little of the philosophy of to-day calls itself voluntarism, or pragmatism. But we are not to forget that Nature is not the whole Universe and that the Will is not the whole Self, either as universal or particular. Motion as the primal separative act may be conceived as the outer Will ever going forth out of itself and determining the physical world.

Our first task is then, to try to run some lines of order through the Cosmos in the sense here employed—to organize its divisions and subdivisions according to a universal principle which, in our view, must be psychical. Any explanation of Nature, which seeks to be fundamental, cannot help going back to its original source in the universal Self from which it once separated and still keeps separating, and whose impress it bears in all its processes, even the smallest.

Part First.

THE COSMOS.

From the very dawn of the human mind it has been asking after the origin of the world. The humblest savage in his folk-lore has his theorem of creation; so has the profoundest theologian, philosopher, scientist. Of course some of the latter give up the problem as insoluble, unknowable, fantastic, and hence useless to be considered. Such a view, however, must be deemed a kind of intellecttual despair begotten of negative culture. The normal mind will grapple with the great Whole of which it is a part; as such a part it must feel within itself, and perchance may get to see in its own process, the process of the All. A cosmogony each man must have, original or inherited, as sure as he is an integral member of the Cosmos. Among his

other distinctive attributes man may be deemed by nature cosmogenetic.

Accordingly, a science of Nature, if it seeks any degree of completeness, will take a look back at its own beginnings. Religion has its cosmogony and usually introduces the creator in the act of creating the world. A Will is thus the starting-point of the All, a person who evokes the universe by fiat. The Hebrew account in the Old Testament is the best known to us of these religious cosmogonies. It is significant that an old Greek poet, Hesiod, has given a kind of evolution of the Universe through a line of shapes of Nature which are also regarded as deities. The book is called a Theogony, and in it runs the idea that the Gods too must evolve from lower to higher. That certainly is a stride ahead of Darwin, though reaching far back into hoary antiquity.

Of course the philosopher likewise must have his cosmogony. In fact early philosophy, notably that of Hellas, deals with hardly anything else. Socrates expressly reacted against it and turned more to mind. His prejudice was evidently shared by his pupil Plato, who, however, felt at last the necessity of making a small cosmogony in the *Timæus*. Aristotle, on the contrary, devoted a large part of his works to the philosophy of Nature, which was revived in recent times by Schelling and Oken, with its culmination in Hegel. After the latter followed a rapid decline of philosophic cosmogony, which was supplanted by the experimental science of Nature.

But the latter in its turn has been unable to keep aloof from cosmogenetic speculation, often wilder than the theologic or philosophic.

The eighteenth century gave rise to what is known as the nebular hypothesis of the evolution of the physical universe. Its currency was largely due to Laplace, the eminent French astronomer and mathematician, who, however, was not its first proposer. Laplace thinks that it was the atmosphere of the sun which cooled down gradually and threw off the planetary bodies. In his *System of the World* he says: "The consideration of the movements of the planets leads us to think that on account of an excessive heat the atmosphere of the sun at first extended beyond the orbs of all the planets, and that it was gradually confined to its present limits." We have here the thought of the sun with its atmosphere embracing the whole solar system (and no more seemingly), and then contracting and successively throwing off the planets. This solar atmosphere is deemed the primordial nebula from which the heavenly bodies of our system evolved one after the other. Such is the basic conception of the nebular hypothesis which has so deeply influenced modern cosmical science. We may call it the conception of the Heliosphere which also revolved, even if slowly, upon its axis, already as a nebula.

Now it is a curious fact that in an obscure corner of Europe, at Koenigsberg, Germany, the philoso-

pher Kant had published a similar but much broader hypothesis, in 1755, forty-one years before the appearance of Laplace's *System of the World* (1796). The philosopher on the border of civilization (we may say) was far more daring than the scientist at the Parisian center (in the dawn of the Napoleonic era). Laplace's words are exceedingly circumspect, he puts his theory off into a kind of appendix as a possibility with which the scientific reader may amuse himself. For it lacks these two requirements of strict science: visible demonstration and mathematical proof. And yet this little thought in a corner has immortalized Laplace far more than his great *Mecanique Celeste*. It has been fertile, it has shown an inherent power of evolution, till it dominates the scientific cosmogony to-day, though of course with some protests.

We should note, however, that Kant's form of the nebular hypothesis is decidedly more universal than that of Laplace, who seems somewhat timid in comparison. For instance Kant did not confine his theory to the solar system, but boldly extended it to the entire physical universe. The philosopher, therefore, reaches out beyond the Heliosphere, and seeks to embrace the many suns and their systems, in fine, the whole Cosmosphere, as it may be called. But this is not all. He has the conception of a single fundamental element (*elementarischen Grundstoff*) which fills all space, and out of which all the heavenly bodies have been formed, and in which

they still revolve. Such is Kant's primeval matter or protoplasmic stuff, the original element of planets, comets, and worlds. In connection with it, one cannot help thinking of ether, which from its previous dark background seems to be coming into the forefront of recent science.

Two other scientists of great name belonging to the eighteenth century, Buffon and Herschel, are often regarded as suggesters of this nebular hypothesis, and are mentioned in company with Laplace and Kant. Sir William Herschel, by means of his large telescope, first studied in detail the nebulous masses of the Heavens and made them an important part of astronomy. He too saw in them the primeval form of the origin of worlds. Thus the new cosmogony, springing up at very different points in Europe, seems to be an utterance of the age, a characteristic note of the eighteenth century, which was a time of revolution, not only in states, but in ideas. The old origin of the Cosmos, theological and philosophical, can no longer be accepted; it must be made scientific in accord with the incoming era. A shred of matter of the extremest tenuity is taken as the starting point of cosmical evolution, which thus antedates organic evolution, the work of Darwin. But besides and even before Matter, something else has to be assumed: Motion in some form. For the separating power must exist in advance of the separated result, which is that slender gossamer of a nebula with which the

Cosmos is conceived to begin, and to start moving.

The nebular hypothesis, accordingly, assumes the two primordial cosmical elements, Motion and Matter. But whence do they come? Certainly such a question is not to be suppressed. Moreover, the assumed motion of the evolving Heliosphere is circular, ever returning into itself on its own axis. In other words, that Motion from which all other kinds of Motion are generated is the rounding one, yea the self-rounding one, which is the original creative form, parent of all other forms of Motion. But how did it get to be? Rectilineal Motion is derived, finite, not universal and primordial. It is true that Matter is conceived to attract in straight lines from the center, but such Matter is divided, limited, made up of separate bodies, between which is limited or special Motion. This comes later than the original circular Motion of the Universe, from which all other Motions are taken.

Such we may consider the first Motion, whose counterpart is the first Matter already indicated, which has been sometimes declared to be a million times rarer than hydrogen, the lightest of the chemical elements and the basis for the comparative weight of gases. This most etherial of substances as a nebulous mass is observed to take a spiral form, it seems to whirl primordially, as if that circular Motion were its first impress from the universal Ego which is also self-returning or a circle within

itself. Such then, we deem the primordial source and indeed form of Motion: it is the process of the All-Self externalized, thrown out into the world, opposite to itself, yet retaining in such opposition its own movement. Very significant is it that the first Motion of Nature is circular, and also that the first of Nature is Motion, the earliest eject or utterance of the Pampsychosis.

And here we may summon up an image which, even if inadequate, has its uses. More or less distinctly is the physical Universe conceived by the Nebular Hypothesis as a vast wheel (or rotary sphere) which as prototype reproduces itself in lesser wheels of the same general pattern (suns, planets, moons), all of which make a colossal system characteristic of the Cosmos. This we shall study later as the Systemic Cosmos. At present, however, our attention is directed to the first Motion as circular, from which all other Motions, curved and straight, are derived—a fact which we shall find repeated in every kind of finite machinery, notably in the steam engine, whose aim is primarily to produce a circular movement, which is the generative source of its variously directed powers. Thus it may be said to partake of universal Motion, or the Motion of the Universe. Moreover, in this illustration we are led to see the mechanical element in the Cosmos, which properly embraces the science of Mechanics, celestial as well as terrestrial, both being forms of the one original

cosmical machine. Sir William Herschel, studying and co-ordinating the facts of the Milky Way, compared it to a grindstone, which had indeed a cleft in the middle, but which to him represented the wheel of the Universe apparently revolving with primal Motion. Before him Wright had suggested the same idea, and it occurred also to Kant's speculative mind. The wheel is indeed a great thing in all our terrestrial machinery, but it becomes far greater if there be a cosmical wheel as the grand mechanical prototype, or the wheel of the Cosmos. In such a case the huge Ferris Wheel of the two greatest World's Fairs becomes an ideal pattern or artistic type not only of Earth's but of Heaven's mechanism, possibly also a colossal symbol of our oft-defamed mechanical age.

Undoubtedly Herschel's universal grindstone calls up difficulties, both scientific and philosophic, and we learn that the author himself receded from such a view in his later years. Still it has its persistent significance, and continually recurs under one form or other in astronomical theories, yea in nearly all attempts to figure the physical universe.

But, dropping this speculation for the present (we must recollect, however, that all Natural Science is getting speculative in these days), we come to a more exacting question concerning the treatment of the Cosmos in the sense here used: What are its right divisions? These must be so conceived and formulated that they reveal its essential process.

In grasping the Cosmos we have to start with the separated Universe, which, however, is striving to overcome its separation and to return to unity through gravitation. So it comes that gravitation, the attraction of separated Bodies for one another, and their strain to get together, may be regarded as the fundamental pervasive phenomenon of the Cosmos. To be sure we shall find that separation in the form of resistance and repulsion will assert itself against the unifying power of gravitation. Thus the Cosmos becomes the arena of struggle between antagonistic forces. But in the end gravitation will be able to systemize the colliding bodies and to bring them into an harmonious order, such as we behold for instance, in the Solar System.

The exposition of the Cosmos from the foregoing point of view, will comprise the following chapters.

(I) The Cosmos as elemental, in which Nature's primordial elements—Motion, Matter, Magnitude (or Measure)—are taken as immediate or as they are in themselves; that is as pure Motion, Matter, Magnitude (Measure). These may also be deemed the ideal or universal elements of the Cosmos since they underlie all its manifestations, which indeed are next to be looked at.

(II) The Cosmos, as particularized, real, finite and hence colliding, in which the clash of the elements take place. For instance when a body impinges on another body or falls to the earth, there is, in general, a collision between Motion and Mat-

ter, a cosmical fight in which one or the other side is overcome in some kind of rest or agreement of peace. Our earth especially with its finitude is such a field of elemental combat, in which, on the whole, Matter triumphs over Motion and brings it to a stop, at least for a time and in a limited way. The Motion of a stone lying at rest on the surface of the earth, is indeed overcome by its Matter; still the material stone is carried by the earth around the sun in a Motion never-ending, as far as we know. So Motion in this new system triumphs over Matter. This introduces the next stage.

(III) The Systemic Cosmos, or the Cosmos as a system in which the collisions of the particularized Cosmos for the most part are harmonized. In the Systemic Cosmos there are still finite moving bodies, but the earth does not collide with the sun or with the other planets. Yet they all are endowed with Motion and Matter, which elements showed so much antagonism in the previous (second) stage of the Cosmos. Still it is not said that there are no collisions in the celestial spaces. Our earth for instance dashes now and then into a comet, and is rained upon by the meteoric showers; even stars are supposed by astronomers to blaze up in some cosmical crash (like Nova Persei). Still the great fact of the present stage is the harmonious system of Motion and Matter, along with their Magnitudes, which are now realized in millions of bodies scattered through spatial infinity. Yet these bodies

representing all the diversity and separation of the incorporate Cosmos reveal an order and follow a law, in fact one fundamental law, that of gravitation.

We are not to forget that the Cosmos presupposes the primordial separation of Nature, with which the start has to be made in grasping the totality of physical science. Nature, separated from the All, shows first the striving to get out of her separated state, shows her aspiration (we may conceive) to return to unity. This is the original of Nature's Motion. The universal striving of the Cosmos as incorporate has been repeatedly noted as gravitation, which is Motion embodied and carrying or perchance pulling all bodies together. The outcome is that Motion and Matter are united into a system.

Such are the three stages of the Cosmos: the elemental (universal), the particularized (real as colliding), the systemic (real but harmonized). These stages, though distinct, constitute a process together, yea a psychical process in form. The Cosmos opens with Motion as elemental, which is circular in its primal conception; it concludes (as systemic) with Motion as real which is likewise circular, being such both as axial and as orbital in the heavenly bodies. Thus the development of the Cosmos goes back to its beginning and makes a circle in its conception, showing a deep correspondence with its Motion, which as system is also circular, realizing therein

its primal form as elemental or ideal. So we conceive the Cosmos as here unfolded, rounding itself out into its complete process, which, however, is but the first stage in the great totality of Nature.

These distinctions, which appear quite abtruse in their naked statement, will be better understood in their concrete application to natural phenomena, which, however, reveal in their details the process of the whole. Some of these more important details are what must be looked at next.

CHAPTER FIRST.

THE ELEMENTAL COSMOS.

Descartes said that he could construct the physical world out of the two elements, Motion and Matter. These he evidently regarded as wholly diverse, as the original dualism of Nature herself. They are not interchangeable, one cannot take the place of the other. To be sure Motion can be imparted to Matter from the outside, and then can leave it; their relation is a purely mechanical one. Descartes likewise ascribes to Motion all change in Matter, all diversity of its forms. Motion is the *movens*, Matter is the *motum*. This is largely the present view of scientists; so it comes that Descartes is often declared the father of modern Natural Science, which for the most part bases itself upon these two elements and their mechanical and physical relations.

Such is the vast generalization used by a great philosopher at the beginning of a new epoch in the study of the physical universe. Plain enough are Matter and Motion as they appear in thousands of instances before us; but that all the Cosmos to the remotest star is composed of those two ultimates, is not so manifest. That is, we have here again theoretical or speculative principles underlying our conception of the reality. We may indeed

call this elemental dualism of Nature the scientific consciousness of our time. It is deemed the spirit or reason indwelling all the manifold phenomena which meet our senses. It is the Logos of Nature which the student is at last to find and to commune with; in a sense Nature may be said to think, and he is to think her thought after her, or perchance with her in all her subtle metamorphoses. The scientist becomes natured (*naturatus*) in his mind, and that is one of his powers.

It may be added that some writers have sought to get rid of the foregoing dualism by a reduction of the two elements to one, which can be brought about in two ways: by reducing all Matter to Motion, or even by reducing all Motion to Matter. But the scientific trend is to maintain the irreducible dualism of these twin elements of Nature.

Motion and Matter are undoubtedly to be regarded as elemental; cosmical elements we may call them. Of Nature in herself they are ultimates, irreducible; but that does not hinder us from asking whence comes Nature with these primordial twins of hers? Already we have named them the Separating and the Separated, with a suggestion of their psychical origin from the universal Self, which produces them or separates them out of itself as a necessary part or stage of its complete process. Nature as the separation from the All must still be of it and in it; she is different from it, yet this difference must be its difference. Nat-

ure thus may be deemed negative to her source, to the universal Self or Pampsychosis; hence she is the Negative as existent, as real; this aspect of her has been emphasized much by Theology. On the other hand Nature is an integral part of the universe as Self, and must show herself such; hence if she is negative, she is likewise self-negative, self-overcoming, and is ever on the return to her origin. This we have already tried to state as the deepest fact of Nature: as the opposite of the All-Self she is inherently self-opposed; dialectical we may designate her, as some of the old Greek philosophers did not fail to observe. Consequently, too, Nature is dualistic, divided primarily into Motion and Matter, which we may well regard as scientific ultimates., but not as psychical ultimates. These twins, named the Separating and the Separated, are not only divided from the Universal Self, but from each other; they are the two first-born protagonists on the arena of the Cosmos. In a manner the whole panorama of Nature is their contest, or rather the contest of their multitudinous ever-varying shapes, till the last one vanishes from the scene in a new order.

Motion and Matter are, therefore, naturally ultimates, opposites, yea mutual contestants for supremacy; Motion may be said to triumph when the material Earth cannot stop it, but is borne by it without cessation in a victorious orbital sweep around the Sun; Matter may be said to triumph

when the same material Earth halts the moving body on its surface and compels it to be at rest. Still each of them, Motion and Matter, remains invariable, without increase or decrease in the physical universe; whatever be their local variations, the sum total of each is the same. The turn of my hand shows that I am able to tap the whole reservoir of this universal Motion and use a little jet of it for a moment, but that little jet is not lost when I stop using it, for it still belongs to the grand totality. And this hand of mine as a material object has been wrenched off or sliced off temporarily from the never-varying cosmical mass of Matter of which, however, it still remains a little fragment. It is evident that with Matter and Motion goes the measured Magnitude, or their Measure; both are quantitative as well as qualitative; every separated portion of each bears in it a more or less; it cannot help being so much Motion or so much Matter measured off from the whole. There is a quantitative relation of each part to the entirety; the earth has been weighed, the planets have been weighed, the Sun himself has been weighed; but we have not yet put into the balance the totality of Matter, though it too must be heavy as against Motion. The astronomer, when he gets the Cosmos weighed, will find its quantity, yea its absolute quantity, the final How-muchness of it. But we can already say that it has magnitude and hence measurability.

Accordingly the present book is going to add to the two preceding a third cosmical element which it will call Measure or Magnitude measured. This agrees well with the scientific mind whose first impulse is to measure any fresh appearance of Motion or Matter. Indeed science has often declared through its authoritative mouthpieces that such Measure formulated mathematically is the only real knowledge of Nature which we possess. If Motion and Matter be the Separating and the Separated, then we have to ask in both cases, How great is the separation? Impossible to say, at least at present; still the *quantum* exists in the thing as well as in the thought.

Accordingly we shall consider the elemental Cosmos to possess a triplicity of elements as follows:

I. Motion.
II. Matter.
III. Measure.

At the same time we must not regard these three elements as wholly disparate and apart. Matter and Motion for instance are often made too incompatible. Yet what is more common than to see the Motion of Matter, or the moving of bodies? The fact is they belong together, even as opposites, they are mutually related through their opposition, wherein they are alike. Still further, magnitude with its Measure is a necessary third, a mediating element which brings

Motion and Matter under order and law. Most significant of all the laws of Nature is the law of Gravitation; it has as its three components Motion, Matter, and Measure. That is, the attraction (Motion) of bodies (Matter) varies inversely as the square of their distances (Measure). All movements of material bodies are, therefore, measured by themselves, or we can say by Nature herself, for this only expresses her act in the given case. In like manner, though under different conditions, the law of falling bodies gives the Measure of the Motion of Matter—the velocity (Motion) of a falling body (Matter) is proportional to the duration of its fall (Measure). In Kepler's third law the same three cosmical elements are seen in a process together which is ultimately the Motion of Matter measured in their magnitudes—in the present case the law pertains to the planetary system. Manifestly Nature legislates order into Motion and Matter through Measure, somewhat as we, by a curious analogy of speech, hear of legal measures in human legislation.

Such are the elements of the Cosmos, or in general the elemental Cosmos, its universal ideal principles which are indeed to be realized, and in such realization to be ever-present in Nature. They are the foreground, or if you prefer, the background of all physical science as well as of all schemes of construing the physical totality. Not only in the Cosmos but also in the Diacosmos we shall meet

these elements but under a different form (say as radio-active); nor will they fail us in the Biocosmos or the vital world (say as cyclo-active in the individual body). At present however, these three elements—Motion, Matter, and Measure—we shall unfold as purely cosmical, setting them down where they belong at Nature's start.

I.

Motion.

Motion, then, we have to grapple with as the first element of the Cosmos, the earliest appearance of Nature, the primal externalized form of the universal Self as internally self-separating and making itself its own opposite. Motion is grasped psychically as the inner self-separation of the All manifested outwardly in Nature; for Motion, if we inspect it closely, we find to be ever separating from itself and going on and on, thus showing a divisive and dualistic character within itself. So we have named it the Separating, always active, in contrast with the Separated, which is Matter passive yet necessarily resisting the action of its opposite in order to be passive.

Still we are to observe that Motion, though ever separating and going onward out of itself, is also striving to come back to its start, to its primal source. Thus, while it is self-dividing it has like-

wise a self-returning bent, seen in its tendency when free to move in circles, which, however, can be only an external return, not an internal, for Motion as Motion can never get back to its origin, to its separation, and thus become self-originating, though it strives eternally for just that. Then it would be Ego, Consciousness. Still we are never to leave out of mind this aspiration of Nature so often emphasized already and manifested primordially in Motion. The primal nebula, now so much studied, as the earliest form of the visible universe doubtless moves, turning on itself—how else can it move? But this is a theme belonging far ahead; at present we have enough to do in wrestling with the thought of pure Motion.

One of the hardest problems which we meet in the thought of the Universe is this primordial separation of it, which makes it another to itself, that it be completely itself. This requires an universal otherness which is a part or stage of the Universe, inside of it not outside else it would not be the Universe. The All disrupts itself in twain and ejects its opposite which is its own, yea is itself, being a necessary part of its total process. This conception of an universal otherness is just the conception of Nature as a stage of the triple process of the Universe, usually formulated as God, Nature, Man. Nature we may deem the Unself, yet with the All-Self immanent in it, which Spinoza named *Deus sive Natura*, and also *Substantia*.

The original of Motion, in its psychical aspect, is the Ego as Will, also the separative stage in its sphere. Our consciousness has Motion within it; we watch it separating itself from itself and making this separation its object. Now it is with this act of our own Self that we can recognize the act of the All-Self as creative of Nature and of Motion. We have to re-create the primal creation of the world, if we are to think it. This mental act is often called the seeing God in Nature; He moves, separates, determines not by special intervention, for He is just the separation of Nature and all her movements in Himself; in the divine totality Nature is not outside but inside, a stage of the universal process.

Motion, then, we may consider as the primal element of the Cosmos, as the original push of it into being, which push is forever going on. Motion as universal cannot stop of course, cannot even be increased or diminished in total amount. Now, it is a curious fact that an old Greek philosopher, Zeno the Eleatic (already alluded to), denied the existence of Motion. Nature could not start, and so in reality could not be at all. Zeno saw and showed the inherent self-opposition in Motion; his reasoning was that since it was self-contradictory or self-negative, it could have no existence. His supposed purpose was to get rid of all separation, all multiplicity, all appearance, in fine to get rid of the external world and to restore the unsep-

arated One of the Eleatic philosophy. This inference of Zeno we need not accept, but we have to accept the contradiction which he uncovered in Motion, and which is the deepest fact of it, yea of all Nature, which we have already called dialectical. Both the name and the thing are derived from ancient Zeno, who has the merit of uttering this primordial insight into Nature, and starts natural philosophy. To be sure he made a mistake in his negative conclusion, if he really inferred (which has been doubted) from the inner contradiction in Motion that it had no reality, whereas just that is its reality It may be added that a modern German philosopher of note, Herbart the pedagogical thinker, has also denied Motion on account of its innate impossibility.

But what lurks in this first element of the Cosmos? What can be unfolded out of it? Space and Time are often declared to be the primordial forms of Nature, the earliest shadows cast from her creation. There is no doubt of their very primitive character physically; indeed of such extreme tenuity is their reality that it has often been denied. Still they remain as it were in the dim background of the Cosmós, very persistent even if very elusive. Space has been humorously termed a kind of fog spread over the universe, reaching from the infiinitely large to the infinitely small; quantitative it seems, yet hardly measurable as a whole in itself. Time too has the infinite outstretch

from the present to the past and to the future; who can tell its æons? Both are possessed of a sort of indefinite quantity, which persists in its very indefiniteness. The scientist has not yet, we believe, asserted that there is an invariable amount of Space and of Time in the Universe, as he affirms of Motion and Matter. Quantity is, indeed, a phase or stage of Motion along with Space and Time.

So it come that we find in Motion as the primal element of the Cosmos a triple order which arranges itself as follows: Space, Time, Quantity. All of these must be treated here in their universal aspect.

By way of illustrating pure Motion, Newton's *Principia* may be cited, whose theme is, according to the caption, the Motion of Bodies (*De Motu Corporum*). Moreover it is this Motion of Bodies which he proceeds to measure mathematically, so that his great work is constituted of the three basic elements of the Cosmos, being in general the Measure of the Motion of Matter. Here, however, we are seeking to grasp Motion in itself, as primordial and elemental in Nature; this Motion Newton takes for granted in his epoch-making book, which indeed anchors in law the Cosmos. Newton also assumes the Body or Matter, and likewise its Magnitude as capable of being measured. This measuring of the Cosmos is what his genius specially seized upon, being cognate with it;

in particular his measurement of the cosmical push of Matter toward unity has been most significant and far-reaching. But it is necessary to get back to his pre-suppositions, and to set them forth as they are in themselves, if this be possible. Such an exposition cannot be quantitative or mathematical, but psychological at bottom; its function is not to measure, but to give the foundation of Measure and show its place in the cosmical process. Newton in his book barely touches upon abstract Space and Time, not manifesting a strong grasp therein, we have to think; that was not his true field. Still they have to be considered (along with Quantity) if we would penetrate to the process of Motion.

I. Space. Many predicates rush in upon us when we try to tell about Space; in fact it might be called the predicable as such, existent, everywhere at hand ready for use. The physical universe is spatial and all things in it; Space is verily the primordial predicate or category of Nature; hence we put it first in the long evolution of her forms, all of which, however remain spatial to the last.

The primal thought of Space is its potentiality. Whatever takes place or exists is conditioned by it; the Cosmos is conditioned by it at the start, and becomes through it possible. Without Space neither Motion nor Matter could be; it is their potentiality, and of all Nature, whose shapes rise out

of it yet remain in it as their earliest prototypal shape, of which they never get rid. The highest living body is still spatial. Space, however, can hardly be called a shape but the absolutely shapeable, wherewith the vast multiplicity of Nature's shapes has to begin. So it is the grand potentiality which is to be real, and yet we must think it too as a reality. Space is not a subjective phantom of my own; I have indeed to re-make it in order to know it, still it is already made and exists in own right. The Cosmos could not start without Space, nor my individual Ego could not evolve without it. I too am spatial internally, and for that reason I can know it or rather recognize it as my own, seemingly after the long estrangement. Space is accordingly a part really, the first step of the lengthy evolution of Nature.

In the thought of Space we have then to hold together the opposites: it is the potential as real, it is the total possibility of Nature and also an actual existent object. Very difficult is it to grasp this contradiction in the unity of thought; so it comes that many minds have denied and still deny the reality of Space, considering it to be subjective. That would of course destroy its place in Nature and seriously breach her evolutionary line. Most famous of these denials has been the Kantian, which still has its followers, indulging, however, in many variations.

If Space is the all-embracing potentiality of total Nature, its most direct specific potential relation is to Motion, as the primal cosmical element. Hence we put it under Motion as the first stage of the latter. It is the infinitely divisible, the absolutely penetrable; thus Motion as the ever-separating finds no resistance in Space. Not only no resistance: Space is already Motion implicit, not yet moving indeed but the infinite capability thereof. From this point of view Motion is Space made explicit, actual. Space is latent Motion, a mode of Motion, existent long before those other modes of it, Heat, Light, Electricity. Using a recent term of Science, we might call Space the primordial potential energy of the Cosmos.

Other predicates we may apply to Space, which, however, amount to quite the same thing. It is pure externality, not only outside, but self-outside; it is pure extension, it must be beyond itself to be itself; it is the void, empty of all except its own emptiness; it is simple continuity, permitting any limit which, however, is no limit, for it is always beyond. We speak of the infinity of Space, which has in it the spatial contradiction; we seek to limit that which is indifferent to limit, whose boundary is always over the boundary. It may be deemed the original Chaos, in which no lines of order are drawn, without being at once obliterated. In the old Greek cosmogony, Chaos was held to be the primordial mother of the Cosmos.

There is no doubt that the foregoing attributes of Space are contradictory and strikingly exhibit the dualism of Nature in its first appearance. They may be pretty well summed up in the statement that Space is Motion inactive—conceived but not born. Space has been termed Nature's quantity, but it is not yet quantity though quantifiable, the possibility of quantity—which is to be discussed later. It is indeed indifferent to quality, even to a qualified quantity, which by the way is just its quality. If we ask, how far does Space extend, this *how far* is a qualified quantity that cannot properly be applied to pure Space, which is not to be enclosed without enclosing the enclosure. Hence Space cannot be imaged, as it also is outside the limits of the imagination.

And now in this primeval Chaos can there be any order, or at least the possibility thereof? Assuredly, if the Cosmos is to unfold out of it. We hear of the three dimensions of Space—a suggestion of order. Some kind of organization is hinted in Point, Line, and Surface, all of which are purely spatial. And then a science of Space has been pointed out in Geometry, which, however, belongs to a more concrete stage of the Cosmos, to Measure, as we look at the subject. Still there are lines of order in pure Space, which we shall try to draw.

1. *The Spatial Process.* Have we the right to put a process into what is said to be a mere processless continuity? Undoubtedly the contradic-

tion again rears its head. Still inactive Motion as spatial must show the possibility of itself, of its process even as potential. Let us see if something of the sort cannot be glimpsed in the following.

(*a*) Space as the extended, or *pure continuity*. Already this has been sufficiently set forth in predicates. Here we need only say, Space as pure outsidness is negative to itself, is really the opposite to itself. This brings us to the next.

(*b*) Space as the unextended, or *the Point*. The usual conception of a Point is that it has position, but no extension, no dimensions. It is posited by Space, yet in Space; it is the negative of Space but still is spatial. Space as outside itself calls forth its opposite, the Point. The definition of a Point has always given difficulty since it is the spatial contradiction of all Space. That is indeed what makes it a Point, verily a turning-point. For the negation of Space, the Point, is still spatial and hence continues.

(*c*) Space the unextended as *continuity*. This is involved in the statement that the non-extended Point is spatial and hence continuous, that is linear, though not yet a line. Or the Point having negated extension goes back to it and gets extended. But this is no longer pure continuity (the first stage) but the Point as continuous (the third stage), wherein the Point may be said potentially to vibrate between two extremes of itself, as it will do really in Time.

Such is the primal process of Space, still kept spatial. Nevertheless the fact is to be noted that it shows the Psychosis, though more remote from the Ego than any other process in the universe. There is the pure potentiality of Space, the sepation, and the return. And the source of this psychical process even in Space should be seen. The universal Self or the Pampsychosis unfolds the opposite of itself in Nature and so in Space; but this opposite of itself is a part of its own supreme process and bears the creative impress thereof, which must also be spatial.

2. *The Spatial Dimensions.* We have just seen the Point as continuous, returning as it were to the continuity of Space, and completing its germinal process. But the Point is also negative to continuity and ends it, ends it in a Point, causing it to lie between two Points and thus producing the Line. The latter being thus measured, becomes itself a spatial measurer, a dimension of Space which has three of them.

(*a*) From Point to Line. Such is the first dimension of Space; a Point can hardly be called a dimension. We may conceive it seeking to get rid of its contradiction as spatial and non-spatial, and producing the Line, which, however, returns to the Point, and thus is the potential measurer.

(*b*) From Line to Surface. The Line is also non-spatial through its origin from the Point. But it has also continuity, and its whole continu-

ity must be continuous, and so it produces the Surface, which, however returns to the Line. A Line running a plane through Space is measuring it with a new dimension, the second.

(*c*) From Surface to the spatial Solid. The Surface also is non-spatial, but it is continuous too, and its entire continuity shows itself continuous, thus producing a spatial whole which, however, returns to the Surface with its lines, and is thereby limited. This, too, is properly a dimension of Space as completed extension, we may call it a spatial (non-material) solid

It will be observed that the spatial dimensions spring from and go back to the line as their basic measuring principle. The line must be regarded as the primal measurer, drawing the first limit in and upon Space, itself the first element of Nature. A great mathematician has said that "any magnitude whatever can be represented by a line." It is the primal potential magnitude, from which all others are evolved. It is the first dimension of the physical universe and starts the measurement of the same. Still the spatial line is not yet Measure, though its possibility. The line itself must be measured ere it can be really a measurer, and so measure itself. The surveyor's chain is a measured line whose function is to measure spatial lines as yet only possible. Measure proper is a later development than Space, later than even Matter. Still we are to note the Line running

from Point to Point in Space as the primal dimension of Nature.

3. *The Spatial Totality.* Space in the solid has indeed returned to continuity which extends in all directions, but this is not the pure continuity with which we started. Space has again asserted itself, we may say, but is limited in all directions by Line, Surface, and spatial Solid. But now we see the three dimensions, which hitherto have been separate and different in character from one another, becoming united and alike in character; they are even interchangeable, yet are separate, being always three distinct dimensions. These are now called (*a*) Length, one linear dimension; (*b*) Breadth, another linear dimension; (*c*) Height, the third linear dimension. We note here that the line has become the one basic dimension, the common measurer of Space.

Each of these lines can take the place of the other, but one cannot absorb or displace the other; the exchange must somehow be mutual. It is spatially indifferent which direction or dimension I consider Length, Breadth, or Height; still I must have all three in the spatial Totality. The three form a whole, we might say, a process together, in which each is indispensable, though all are qualitatively alike. We have to think that Space or its material embodiment must have three dimensions, no more, no less; it is the spatial trinity and in its xternal way bears the creative impress. It is the

quantitative Psychosis of which each stage is what the others are, though all have to be. The legs of the tripod are identical, but the entire vessel would topple down if one were missing. In like manner it requires three straight lines at least to enclose Space, to make the line return into itself and form the triangle.

Space has thus in its way revealed an order. The spatial Totality goes back to continuity, which is now organized through the spatial dimensions. These put limits upon Space, which, however, at once show themselves to be in no limits, and Space is again the unlimited, yea the illimitable. And yet it most passively endures every limit without resistance. What is the result? Space cannot be quantified, but is purely the quantifiable; it is the unmeasured which is yet measurable; the possibility of all Motion, it does not move.

Yet as the negative of itself, the Point, it has to move and to get out of itself, whereby it is no longer Space but Time.

To the immediate vision, Space is partly occupied with bodies, between which seems to lie empty extension. The question has often come up and will come up again, Is Space filled with something—perchance with Matter of the greatest tenuity, that ether which seems to be the present pivotal problem of Science? Or can it be said that Space itself is material, perchance the primordial protoplasmic body of all bodies? Then is

Space limited? or is it merely the potentiality of all limits, hence not yet to be thought as either limited or unlimited? It certainly appears to elude both of these predicates. The dialectical play of Nature begins with Space when grasped either as finite or infinite. And since the mind must also be deemed spatial (otherwise it could never conceive Space), the same dialectical play becomes mental and shares in the dualism of Nature from beginning to end.

Some of these questions will again arise, particularly that of ether, which, however, in its fullness belongs to the Diacosmos. Here we are to see Space as the first of Motion, its possibility, not yet its reality. At such a statement, however, that dialectical sport springs forth anew, lurking in the query, Is Space then real or unreal? Or is neither predicate applicable? Already we have noted that eminent philosophers have denied the objective reality of Space, and with it of the external world.

But the true movement of Space is Time, in which the primal indifference of Nature passes into difference; hence the vast diversity of the Cosmos makes a start in Time, which is thus the second stage in the process of Motion.

II. TIME. The intimate connection between Space and Time has long been recognized. The Point is passively continuous in Space which lies between Point and Point, but continuity gets pointed in Time, which is an active never-ending

line of separated Points; thus we may conceive Extension passing into Succession. The Point is subordinate in Space which has to subsume its own negative, but the Point is triumphant in Time, which is the ever punctuating Now. Accordingly Time is the always Separating and so is the first reality of Motion, Space being its potentiality. Motion, taken in its complete process, must overcome the unseparated or the purely continuous as Space, else there could be no real separation of the universal Self and hence no Nature.

What we called the Totality of Space with its three dimensions exhausted the Point as spatial or continuous. There arose an order in Space, but this order being purely spatial, had no real limit, and so fell back into chaos. The Point, the negative of Space, must get reality, which it does in Time, and must build a new order, which has to overcome the blank passive continuity of Space. The Point is the turning-point of the transition of Space into Time. We saw it also as the pivot of the germinal process of Space, which showed the three stages: Continuity, Point, return to Continuity in the linear. But Time has a different germinal process as we shall see later.

Space seems to hover between the sensible and the supersensible, even between the real and unreal; we come to see it as limited, but this limit vanishes easily into the unlimited, where fleet imagination cannot catch it. Time as the ne-

gation of the extended is hardly visible, yet is present, yea, is an eternal presence. Time must be deemed more subjective than Space; objectivity has been refused to both by some minds. Time through its self-separation resembles the Ego, but it has no complete self-return, being continuous just in its separation. Thus the Ego includes Time, but Time does include the Ego, which, though temporal, is also the restoration out of the temporal. The Point in Time is self-repellent, it can no longer stay quietly with itself, as in Space.

Time has likewise the dual, contradictory character, which is in Motion, and indeed in Nature. It is the most fleeting of all creation, yet the most persistent. When I look, it is gone, and yet when gone it is back again. Which is it, Being or non-Being? While it is, it is not, and while it is not, it is; the contradiction between the Vanishing and the Permanent is Time's very existence. It is the form of the Cosmos as perishable, yet also as eternal; Nature, Man, the Universe, are ever dying in Time, yet ever being born again in Time, we say; rather they are temporal, finite, evanescent, but likewise enduring, negating their negative Time, which is in them rather than they in it. The so-called stream of Time courses through them, quite as much as they through it.

The Point is the negation of continuity, yet is continuous in its negation, and so rays out into a line of ever-recurring Points. From this aspect of

it Time has duration endless, or is always ending yet always beginning again. It is the image of complete self-alienation, yet forever in pursuit of itself and never overtaking itself. Time manifests the mighty striving of Nature to overcome her separation from the universal Self, and in this character will accompany Nature to her close. Space shows not yet such a striving, it is relatively stagnation, quiescent, unborn; it is the potential, the latent, which, however, must become real; it is the Cosmos simply lying alongside of itself and waiting to be a mere empty alongsideness or co-existence; while Time is the Cosmos pushing after itself in all speed, and never catching up, a very active if void afterness. Time is ever moving out of Space, step by step, that is moment by moment; these steps are indeed infinitely short, but the universe steps with them, and is therein divided through and through by Time, which may be hence said puncture (*punctum*, point) the same every moment. A figure of Time represents it as radiant from its central sun, the Now, radiating its separation to infinity both rearward and forward, to past and future.

Here the question thrusts itself upon us, Can this so deeply contradictory Time be put into any order? It seems to be perpetually undoing itself after positing itself, it is the pure act of change, of self-undoing in Nature. Can it be brought into any lines which show that it too has a process,

yea a psychical process, though far off from its creator? Like Space its essence seems to be recalcitrant to any shape, being the dissolver of all shapes. Notwithstanding its breaching power, Time cannot break outside of the All; it is an element, yes, a necessary element of the Cosmos, and hence we must see it in its place and also in its own inner order.

1. *The Temporal Process.* The task is to find and to formulate the immediate germinal process of Time as it appears before us. Doubtless we have subjectively to think it, or rather re-think it, for it is already a thought existent in the Cosmos.

(*a*) Time is primarily the non-extended, the active negation of continuity—the Point as *Moment*. Already we have dwelt upon the pivotal transition of the spatial Point into the temporal. This lies in the self-contradiction of Space, which is thus driven over to its opposite.

(*b*) Time as the Moment is the negation of continuity, but of necessity must continue its negation—the Moment *as continuous*, or the knotted line of Time. Or we may say that the Point as non-spatial must still be spatial or contain Space in order to negate the same, and thus to become itself. Here rises the fact of discreteness of Time, or Time separated continuously. All the extension of Space is compressed into a Moment, yet that Moment in its turn is extended beyond and beyond—a linked chain of Moments.

(*c*) Time is the Moment ever coming back to itself and starting again—it is *oscillatory*. The Moment is always separating from itself yet always coming back to itself. Hence Time is not simply continuous but oscillatory in its smallest division. Thus Time begins already to create shapes and to round them off; it is the pure unfilled form of Evolution, which likewise unfolds from form to form. In Time all has birth and decay and re-birth, these are in Time, we say, but more truly is Time in them, a necessary element of their being. Through Time all Nature becomes oscillatory, and begins to get organized, starting its processes, which are temporal rounds at first hand. The Moment of Time in which you now are is the primordial oscillation of Nature, yet is also yours and contains all your processes. Science seems to be getting more and more oscillatory, or vibratory, or undulatory, or however else it may be designated. Very suggestive is the oscillation of the pendulum as the measure of Time, being the outer visible image of every Moment as well of great periods. Every particle of Time however minute, is oscillatory, and suggests the cycle. Time as continuous we may conceive as a chain composed of links, going out and coming back, oscillating in endless multiplicity.

2. *The temporal elements* (*dimensions*). Such is the new division of Time into what we may call its elements, or possibly its dimensions, since they

have in them the idea of measurement. They are likewise three, indissolubly connected, yet not interchangeable like those of Space which are of indifferent extension, and not of differentiated succession. That is, the three dimensions of Time —Present, Past, and Future—are all different from one another qualitatively, but they form together one process. In Space itself difference could hardly be posited, except from the outside, Space being the indifference of Nature; but in Time difference is posited from the inside, is its reality (hence Time is the second stage).

(*a*) In the knotted line of Time the succession of Moments as real we call *the Present*. It fleets from this Now to another Now, which, however, is just the same, and so is ever present, indeed the Present. Always going, yet coming back, it trembles between Being and non-Being; it strangely arises into vanishing and vanishes into arising, thus balancing perpetually between birth and death. In this oscillatory Moment called the Present we persist, always living and always dying; that is, always oscillating with it, for we are of it as well as it is of us. In this whirl of the Present I exist, for there is no stopping it, and it exists in me, for I too am of Nature and share in this her primordial oscillation.

(*b*) The second dimension of Time measured from the Present is *the Past* out of which the Present has evolved, but which the Present also

evolves. For the Present is on one side the product and on the other the producer of the Past, which it flings backward out of itself. History, Evolution, Knowledge lie imbedded in the Past, and we have to go back and dig them up in order to find out what we are and how we got to be. Evolution is the great watchword of this century; the Present has as its chief task to go back and evolve itself, the Present, out of the Past. Such is, then, Time's cycle here: the Past is always evolving the Present, which in its turn is always evolving the Past. To be sure I make the Past evolve the Present, for that is in me too as well as in itself. Thus the Past also is oscillatory.

(*c*) The third dimension of Time measured from the Present is *the Future*, the unevolved which is to be evolved, the hereafter projected as an ideal counterpart of the heretofore. Both Past and Future are alike in being non-existent, contrasting with the sole existent Present though in very different ways. The Present mediates them, it has been the one and will be the other. Still on the other hand the Present never has been and never will be, it simply is; the three dimensions of Time must persist in their separation and in their process together. When the Present gets to be Future, there is still another Future; when the Present gets to be Past, there is still another Present. On the one side the Future is always going forward, on the other side it is always going back-

ward and becoming the Past through the Present. Thus the Future is also oscillatory in its complete conception and shares in this ultimate essence of Time.

Each of these three dimensions of Time—Present, Past, and Future—has an oscillation as its soul, and now the final fact of them is to be noted: they all together form one vast oscillation, of which the progressive movement is from Past through Present to Future, and of which the regressive movement is from Future through Present to Past.

3. *The temporal Totality.* Corresponding to the spatial Totality unfolds the temporal Totality embracing all the dimensions of Time—Present, Past, and Future. That which was oscillatory in the Moment of Time, is now oscillatory in the Universe of Time, so that the least and the largest are united in one common process. The huge and ever lengthening chain of duration is composed persistently of three links which interlink—not their number but their size may increase. The whole Cosmos oscillates in Time, and that is properly its first Motion, which is ever separating, yet ever seeking to return to its source.

In this temporal Totality or Universe of Time, we may catch certain far-off flashes of an order.

(*a*) The temporal Totality is primarily *Eternity* or eternal duration, without beginning or end. Thus Time strives to reach backwards and for-

wards beyond itself, to its source which is not Time but its creator. Time is thus the pure form of aspiration in Nature, to be sure without inner content. What it aspires for is the All-Self from which it has separated, and is eternally separating. Given the universe, Time has no beginning and no end, being an element or stage of the universal process. With eternity is connected the idea of immortality which affirms the human soul to have within itself the temporal Totality.

(*b*) The temporal Totality as eternity divides in twain and becomes two eternities—an *eternal Past* and an *eternal Future*. These are different from the dimensions of Time already considered—the adjective makes the difference. Moreover each has through this adjective become contradictory: the Past is bounded by the Present and cannot be eternal; so too the Future is bounded by the Present. The result is that immortality is cleft in the middle as it were, and calls up the dual doctrines pre-existence and post-existence, which have caused no little discussion both in the heathen and Christian worlds. Then both Past and Future are non-existent and from this point of view are very hard to eternize. So the intermediate link of Time's chain again appears, but with new power.

(*c*) The temporal Totality is conceived as eternity in the Now, or as *the eternal Now*. This is the sole reality of Time, embracing in its sweep or oscillation the other two ideal elements, without

which indeed the Now could not be eternal. The Now as mere moment is the most tremulous, unstable, evanescent of existences, a flutter of the vanishing. But it persists ever present, and becomes eternal if filled with its own ideal elements, the Past and the Future. You are to do this indeed, but it already lies in the nature of the Now to become eternal. The Now, as we have seen it in the complete process of Time, eternizes itself; and the question with you is, Will you eternize yourself along with it, or live in the moment, in the ephemeral Now. Dante calls up the thought in a passage which tells of Brunetto teaching him how man makes himself eternal: *Come l'uomo s'eterna.*

Still the eternal Now as purely temporal is forever going beyond itself, shows itself unfinished and unfinishable, having always a new limit to transcend. Time like Space refuses to be a totality at last, so that its totality turns out no totality. Here again we again observe that peculiar dialectical play of Nature in one of her forms, that of Time, which is on the one side the most unstable, and on the other the most persistent of cosmical entities. Indeed Time may be called the pure dialectic of Nature, her separation active and real in itself, in its simple isolation.

From a psychical point of view Time is a very suggestive and deep-reaching manifestation. Of the Psychosis in its second or separative stage, Time

may be taken as the universal symbol or outer adumbration in Nature. We put it under Motion of which it is the first and purest realization. One may indeed ask, which is prior, Time or Motion? As we conceive and formulate it, Motion is the first derivation of Nature from the Pampsychosis, and Time is a stage in its process, the second or separative. Time is, therefore, not the whole of Motion, but rather its divider, its quantifier separating it into bits which are yet to be ordered in Quantity. But this is a new stage which must next become explicit.

III. QUANTITY. We are seeking to put into its place in Nature pure Quantity, not some particular amount or quantity of something, which comes later. Quantity is on the one hand a mental concept, yet it is also existent as well as Space and Time. The Cosmos is quantitative as well as spatial and temporal; indeed both Space and Time are quantitative, each in its own way; Quantity may be deemed an evolution out of them, becoming explicit and existent in its own right. These three primordial elements of Nature we put together in this order: Space, Time, Quantity, which form a process that bears a psychical impress. Doubtless this third element seems unusual in such company; Space and Time are the Siamese twins of philosophy and science, intergrown seemingly and quite inseparable; while the third member of the group, Quantity, appears at first

sight an alien. But he will soon get naturalized if treated with some degree of regard and sympathy.

The next point to be noted is that this Quantity is subsumed under Motion, the Separating in the Cosmos; that is, Quantity is a form or stage of Motion. Such a view may seem a little strange at first; but we have become used to the expression that Heat, Light, and Electricity are modes of Motion, which is coming to be regarded as an ultimate, irreducible element of Nature. We may say that Quantity is one mode or manifestation of Motion, among many others indeed. Certainly Motion is quantitative, measurable; Quantity seems to lurk in it as its very essence; in fact many scientists declare that the only real knowledge we can have of Motion or even of Nature is its Quantity expressed mathematically. That is probably going too far, for surely there are qualitative phases of Nature which we can also know, and which are not given by a mathematical formula. Still Quantity is an elemental constituent or stage of Motion and must be put into the order.

Can we see how it comes about that Quantity lies primordially in Motion? We must recall that Motion is Separation, or more exactly the Separating in the Cosmos. How great is the separation, how much? Quantity (*How-muchness* literally) cannot be divorced from any kind of external Sep-eration. Motion, going on and on, is inherently quantitative. So is all Nature, which is the Sepa-

ration from the universal Self to which the conception of Quantity goes back. Underlying every quantitative procedure is found ultimately the problem: How great is this Separation here and now from the All-Ego which is its source? To be sure there is no unit of measure in this primordial Quantity; we cannot tell in miles or degrees the amount of Nature's Separation from her creative fountain; still such a Separation has in it Quantity, verily, the original Quantity, which becomes manifest in Motion as the ever-separating.

There rises another thought in the present connection: if Motion possesses inherently Quantity, this must also show itself in the other two forms or stages, Space and Time. It has been already remarked that each of these in its own way is quantitative, and now we see that this must be true of them as elements of Motion. And there is a distinction between all these forms of Motion from the present point of view. Motion as quantifyable (as the potentiality of Quantity) is Space; Motion as quantifying (as the active process *per se*) is Time; Motion as quantified (as the process finished) is Quantity itself. That is, the completed quantification of Motion is pure or abstract Quantity which, we repeat, belongs to Nature as an objective fact, and is not merely a product of mind applied somehow externally to Nature. The quantitative interdependence of the three elemental

stages of Motion may be summarized in the statement: Motion quantifyable, quantifying, quantified—Space, Time, Quantity.

That these elements lie deep in Mind and Nature may be seen in a small example: *How long did it last?* In this simple question are interwrought Space (*long*) and Time (*last*) and Quantity (*how much*); and they together are conceived as a process or cycle of Motion with beginning and end rounding it out. Neither Space nor Time can completely quantify or measure Motion; that requires the presence of Quantity itself, elusive as it may be. Quantity is measured Motion (not measured Matter, whereof later). Pure Motion quantified is nothing but pure Quantity, as it is in itself (How-muchness). Quantity returns to Space, which is only the quantifyable primarily, and quantifies it, for instance in a triangle, and in other spatial figures, which show a how-much of Space, a Quantum thereof.

Quantity in its present aspect may be deemed the getting of the Quantum; that is, it makes the indefinite elements of Motion (Space and Time) definite, or at least starts that way, by imposing upon them the How-much. It throws a noose around those two wild nags absolutely running at large, quite without restraint. Quantity, therefore, holds up Motion, making it turn back upon itself and thus producing the first standard of measuring, which is to have a great future.

We have already often spoken of measurements and dimensions in connection with Space and Time, and also of Quantity as measured Motion. In order to avoid possible confusion we may say in advance that Measure proper as the third stage of the elemental Cosmos (along with Motion and Matter), is quite different from Quantity, which is not yet strictly mathematical. We may illustrate: a triangle is Space quantified, being so much of Space; it is indeed a pure Quantity, a stage of Motion quantified. But when we say of this triangle that the sum of its three angles is equal to two right angles, we are measuring Space already quantified simply, we are really quantifying Quantity, and have entered the mathematical science of Geometry, which lies in the sphere of Measure and presupposes Quantity. Measure is, therefore, rather the Quantity of Quantity, or Quantity made to return upon itself and to quantify itself anew. This calls forth Mathematics, as we shall hereafter see. Moreover Matter lies between Motion and Measure, and helps produce Measure which then measures it. Motion and Matter are the antecedents of Measure, in the elemental Cosmos, while Space and Time are the antecedents of Quantity, in the process of Motion.

Let us present this subject from another point of view. Mathematics is usually called the science of Quantity; evidently then Quantity must have already an existence in order to be scientifically

treated. In like manner Nature must exist before any science of it is possible. Now this primordial Quantity is what we wish here to grasp in itself and to co-ordinate in its place as a part of the universe. It is presupposed in all systems of Measure, being their condition or original source; Mathematics starts with Quantity as something given or primordially existent, and unfolds its forms, combinations, laws. What we here wish to do is to evolve it into its true place in Nature, to which it belongs; then in due order will follow its developed science which is likewise a part of Nature's science, though by no means all of it. Quantity in this sense is a very abstract, elusive entity; indeed we have to reach back to it out of its embodiment in Matter and then in Mathematics (Measure).

Has this very subtle intangible Quantity, existent before Matter and before Measure proper, any discernible lines of order running through it? We think that it has and must have, and that these lines will be outlines of the psychical process of their creative source. They may be faint and fleeting as they have to cast the shadowy image of Separation itself ever-separating, and to stake off its primal measurements. So we must brace to the etherial task of fencing off into its divisions pure Quantity. Some help we may get at the start by observing that its organization is and must be quite parallel to that of its two kindred elements, Space and Time.

1. *The Quantitative Process.* Quantity holds in itself implicitly Space and Time, which it is to render explicit by quantifying them, by the quantitative Process. We may conceive Quantity returning to the continuity of Space and dividing it up through the divisions of Time which become so many units of measurement. Quantity rounds out Space in Time and through Time. From my eye to yonder house I see Space, so much of it, quantified; there is a kind of oscillation between me and it, forwards and backwards, which is in Time and through Time. So also I look back to an event of my life in the past, and round it out between now and then, that is, quantify it. These stages, separately stated, are as follows:

(*a*) Quantity is *continuous*, and so is spatial—the return to and unity with SPACE. It has no limit within itself, is unbroken, has no multiplicity or separation; it is through and through one and the same within itself. Yet Quantity is not pure Space, but Space quantified, bounded on the outside; it is so much and no more—a limited continuity, or so much potentiality of Motion. So Quantity as continuous comes to an end, in fact it goes over to its opposite and is discontinuous or divisive within itself. That is, being bounded on the outside it is likewise bounded on the inside, seeing that Space or continuity is beyond the limit also, and goes on. Thus separation enters Quantity and it thereby becomes divisible and

discrete—a continuity not of one, but of many ones.

(*b*) Quantity is *discrete* and so is temporal—the return to and unity with TIME in its separativeness. Quantity is now not the unbroken One, but the broken ones which are still the same, each with the other. Continuity has its limit not merely outside but inside; it is the continuity of discreteness, the line of Time with its ever-succeeding moments. Yet Quantity as discrete is not pure Time, but Time quantified—limited yet always transcending the limit; it is discreteness yet always breaking ever into continuity and thus becoming its opposite. Now this opposite is no longer merely Quantity as continuous, for this has become discrete, but discrete Quantity as continuous, or a continuous Quantity limited inside and outside.

(*c*) Quantity has therein become the *Quantum* (literally translated, abstract *How-muchness* has evolved into the special *How-much*). It is the unit of measure, still as general; Quantity has produced what quantifies, or the universal quantifier. Limited continuity (spatial) made successive (temporal) gives the standard by which measurement takes place—the Quantum. In Time Nature has begun to measure herself, but cannot, as she has yet no Quantum, no measuring rod, no surveyor's chain, ever repeating its measurements or Quanta. Indeed the surveyor's chain may be taken as the typical Quantum with its limited con-

tinuity (Space) composed of many separate links (Time), the whole measuring an amount. Or more technically stated, the Quantum quantifies Quantity, and completes what we have called the quantitative Process, which is properly Motion quantified, meted out by its unit of measure. The Quantum in its complete sweep should be conceived as an oscillation or cycle, a starting forth and a coming back to start forth again in the measurement.

We must, however, recollect that in this abstract primal stage the material Quantum as unit of Measure has not yet been reached. We are still in pure Motion, Matter is to come with its concrete How-much. The surveyor's chain is but an illustration taken from the sensible material world. It may be noticed here that the atom which plays such an important part in modern science rests originally upon the conception of the Quantum, since its purpose is to be a unit of measure for the physical universe. Also the ion, the electron, and perchance the etherion, though they put their stress upon other elements, go back to the primordial quantitative idea of the How-much in order to measure and then put together their temple of Nature. Even the Ego may be construed as a Quantum, but of a peculiar kind which turns back and quantifies itself and all other Quanta from this earliest most abstract one to the last most concrete one, namely itself.

A very famous statement of the inherent contradiction of Quantity is found in Kant's first antinomy, which affirms on the one hand the quantitative discreteness of the world (Matter and also Motion) and then the quantitative continuity of the same. Kant's conclusion is negative, denying to Reason, which to him seems to assert equally two contradictory opposites, the power of knowing truth. The fatality in Kant's proof is that he takes the World in two senses. (See our *Modern European Philosophy*, p. 559.) Still Kant has done the service of suggesting two stages of the quantitative process, continuity and discreteness, but he leaves out the third, the Quantum, which may be conceived as the unity and reconciliation of his antinomy.

Every particle we are taught by science to grasp both as millions and millionths, infinitely continuous and infinitely discrete—that is practically the Kantian antinomy supposed to be unthinkable by virtue of its contradiction. Still we do think it and employ both its opposite sides constantly. But they should be united in the Quantum, the original ideal unit for measuring the universe. This is the basic principle underlying all mensuration, of which we may note certain applications, made as it were by Nature herself, in the following item on Quantitative Dimensions. The one ideal of measure or the universal Quantum is thus seen in some of its real forms.

2. *Quantitative Dimensions.* These may be taken as quantifiers of Motion, and they are manifold. They are not so definite or inherently necessary as are the dimensions of Space or of Time, which are just three and no more. All moving bodies may be deemed quantifiers of Motion, marking off so much Motion through so much Space in so much Time.

(*a*) The heavenly bodies, Earth, Moon, Stars, are the most immediate quantifiers of Motion, and thereby measurers of Time. They make their cycles and thus round out a period—day, month, year. Nature in this way gives the first real Quantum, or Motion quantified.

(*b*) To these dimensions given by Nature, Man adds his own, dividing them arbitrarily for his special purposes. For instance the natural cycle of a day he separates into hours, minutes, seconds, which are artificial repetitions of what is suggested by Nature. Man learns from Nature to quantify Motion, making a Quantum of his own, which always involves the cycle—so much Motion measured or cycled.

(*c*) Nature and Man co-operate to produce what may be regarded as the universal quantifier of Motion—the Pendulum. By it the oscillation becomes visible and the measurer of Time, Space, and Motion, the universal Dimension, in so far as this has yet been realized.

It must be again emphasized that the foregoing

Quantitative Dimensions or measuring units are manifestations in the real world of the original ideal Quantum or primal measure of the All. Each of these cited instances will again come up in their proper places; especially the Pendulum will appear in its own right when we reach the forms of the realized Cosmos.

Out of this multiplicity of Quanta, this varied manifestation of measuring units, we have to march forward to the unity of these units through their inner necessity, to the Quantum of all Quanta. This is a new conception of total Quantity, mediated through its manifold particulars, which must be next designated.

3. *The Quantitative Totality.* Motion is not only Quantity limited or measured but is also Quantity as universal, rising above finite measurements; as such it is pure magnitude. Science declares that the Quantity of the universe is the same, not to be increased or diminished. This implies some kind of measurement; but who measured the sum total of Motion? Certainly not the scientist with all his cunning instruments. It is another speculation or hypothesis, but it asserts the totality of Motion to be a quantified something. It rises from the specific Quanta into the universal Quantum, really the source of the former. But this Quantitative Totality which we have now reached, is not the simple quantitative process (as continuity, discreteness and quantum) which we have already set

forth. It has that process, but something more. It contains many Quanta, which, however, are unified by thought into one totality. The universe is conceived as having the same unalterable Quantity of Motion, though the forms of the same are infinitely diversified, for instance as heat, light, electricity. All these are deemed modes or forms of the one Quantity of Motion. Lying back of the Natural Science of to-day we can often observe this conception of the Quantitative Totality of force, energy and other forms of Motion, and even of Matter. Of this fact we shall briefly note the phases which may be put together in a process.

(*a*) The Quantity of Motion as one and the same, unchangeable in amount implies its *Conservation*. This idea is better known under the name of the Conservation of Energy.

(*b*) Still there must be difference in this totality of Motion; it is particularized, takes many forms, and this is the *Transformation* of Motion (or of Energy.) Still amid all these variations Motion remains so much and no more. Not only do we conceive it to be conserved indestructible, but it becomes a Quantum, a limited Quantity.

(*c*) The Quantitative Totality is thus *a Quantum*, and returns to its first Process which evolved a Quantum; yet the latter is no longer particular but universal. From a unit of measure the Quantum becomes the absolute unit of Motion. Quantity as pure unfolded the special

Quantum which measured it; but this Quantum in turn has become the Totality, not simply as pure Quantity again but quantified, that is, Quantity fixed, limited. So much Quantity in the universe is the universal Quantum, containing all separate Quanta, yet itself a Quantum. This may be conceived to be the original quantitative One, source of all other ones, which Measure, especially Arithmetic, will hereafter take up as given and organize into a mathematical science. Yet this One is likewise All or universal; sometimes it is designated as the One-and-All. But the very expression contains the inherent contradiction of this entire sphere between the Quantum as limited and as unlimited or universal. Still we cannot help employing the thought: when we say that there is so much force or so much heat in the Universe, the statement rests upon the underlying conception of the universal Quantum, or the limited One as unlimited. Here again peers forth that dialectic of all Nature, which has been repeatedly noted.

Accordingly Motion, having unfolded into and through Quantity, becomes contradictory and self-negative. Motion is halted, indeed halts itself, can no longer move, is no longer Motion. It turns to its opposite, it becomes fixed, yea the fixed. What is the result? Motion, having run its course, has stopped moving, as it has come upon its limit. For it is now so much and no more, it has gone so far but can go no farther. The quan-

titative totality of Motion has turned out a quantum of Motion. Motion the ever-separating is crystalized in its separation, and thus becomes the separated—Matter. Motion stopped, limited, fixed, can only be the opposite of itself. The Quantum of Motion even as universal, bounds it, ends it—in what? Not in pure nothing, but in its other, which is the Separated. We do not say that there is a physical transmutation of Motion into Matter, though many physicists are now claiming the reverse— the transmutation of Matter into Motion. And some say that Matter itself may be deemed a mode or form of Motion, in accord with a common scientific formula. Le Bon, the Belgian physicist, has supposed that ether is transformed into rigid Matter by very rapid rotary Motion. Experiment has hardly reached this point yet; but the psychical transition from Motion to Matter is necessary. If we conceive Motion as the Separating, it must of its own inherent nature separate from itself, and negate itself, becoming its opposite, the Separated, which is the basic predicate of Matter. The limitation of the totality of Motion in the Quantum is not a mere external boundary, as if Motion were inside the Quantum, and Matter outside. On the contrary the limit of the Quantum reaches through and through the totality of Motion, and stops it at every point, materializing it to the last atom.

The science of to-day has much to do with

Quantity; in fact it is bent on quantifying all Nature. Such a tendency is certainly legitimate. Still we are to remember that Quantity is not to be clapped upon Nature from the outside, being an inner development of it, an integral part of its process. The Cosmos is inherently mathematical, Nature quantifies primordially, and its total science should take up and unfold the science of Quantity, which we shall hereafter find in Measure. It may be repeated that the present exposition has sought to evolve Quantity and to co-ordinate it in the process of Motion, the most elemental of all Nature's processes. It will come up again, but under new forms and in new relations.

II.

Matter.

The most difficult problem of Nature would seem to be just this of Matter. Whence comes it? What is it? How does it get to be? All are riddles often declared inexplicable. For instance "we do not know and are probably incapable of discovering what Matter is" (Tait.) Lurking in this and similar statements one cannot help perceiving that fatal Kantian category of Thing-in-itself (*Ding an sich*), though Professor Tait hotly disclaims metaphysics. Again we read that "Matter is that which moves," simply the substrate of all Motion, quite unknown and unknowable. A

further reduction is found in the proposition that Matter is "non-Matter in Motion." This quite sounds as if Matter has been etherialized into Motion, though probably that is not the intended meaning. On the other hand Matter has been completely electrified in the pronouncement that it is "only electricity and nothing but electricity." So we have the electronic theory of Matter, seemingly the favorite of Science just now. This view seems to have taken its start from Prof. J. J. Thomson's article (1881) which sought to show that the basic property of Matter, its inertia, has its origin in electricity. It would follow as a result that gravity is also electrical. The difficulty is that electricity is but one form or manifestation of energy, while Matter includes or contains all such forms. Hence there is felt the necessity of rising to a more universal principle than the electron, perchance to the etherion. Such a discussion, however, belongs to Physics rather than to Mechanics, not to the Cosmos but to the Diacosmos, where this subject must again come up, under electricity, or perchance under a new branch of science, which for the nonce may be named ethericity.

As Matter seems to be the sensible fixed entity which moves, why not put it first, before Motion? The activity psychologically and logically is antecedent to the result, the doing is before the done, the moving before the moved, and Motion before Matter. So we may reconcile this fact to our or-

dinary experience. Or in the phraseology here employed, the separating Motion of the physical universe precedes, in the elemental process of the Cosmos, the Separated (Matter), which cannot come into being without the previous act of separation. The same conception underlies the work of so many scientists who are seeking to resolve all material manifestations into modes of energy, or ultimately of Motion. For all energy or force goes back to separation, which may be conceived as the cosmical Will.

Of our Elemental Cosmos, accordingly, we put Matter into the second place, after Motion, of which it is the opposite. Yet both belong to the realm of Nature, of which they are said by many scientists to be the two primordial, but inconvertible elements; beyond them science, it is further declared, has not been able to penetrate. Already we have named Matter in our way the Separated of the physical Universe, while Motion is the Separating, or the ever-dividing principle which has no stoppage within itself. Such designations of them are intended to suggest their origin from the universal Self, whereof all Nature is but one form, or manifestation, or more strictly the manifestation.

Nothing would seem to be more difficult than to define Matter; nothing is easier than to point it out. It is everywhere around us, inviting, yea assailing all our senses; obnoxious to our eyesight, it

is elusive to our mind. Those who have most to do with investigating its secrets are usually the first to proclaim that they do not know what it is. Matter as a category has been known since the beginning of thought, especially since the old Greeks; still it is deemed quite indefinable, if not unknowable. This fact again brings up that peculiar subtlety, or even duplicity of Nature: what of hers seems most open is most recondite; her most obtrusive reality, which is doubtless Matter, turns out as having something in it impalpably ideal and speculative. One result is that several of the greatest philosophers have denied the reality of the material world. The existence of Matter has been questioned, as has the existence of Motion, both being so dualistic and contradictory. But Nature just through her deepest separation drives the mind back to the One-and-All whence she sprang, bearing as her first-born those characteristic twins, Motion and Matter.

We have, therefore, to grasp Matter in its primal conception as a stage of the elemental Cosmos. This does not mean that Matter is merely subjective, merely in my mind. Rather is it the Cosmos which is now thinking, if we may dare the analogy —thinking purely its original speculative forms of which Matter is one, not now its finite phenomenal forms, which we shall see emerge later. To be sure Nature is not a Self, rather is it the Unself of the universal Ego, whose opposite it

is, even if a necessary part of the total process thereof. Nature cannot perform the self-conscious act, though she puts her impress everywhere upon the shapes which she evolves in her long march from her origin to her goal. Again we may repeat, in our technical speech, that Nature unfolds between the Pampsychosis and the Psychosis, between the universal Ego and the human Ego, and builds herself psychically, in accord with her creative source.

Undoubtedly the thinker has to re-think the Cosmos thinking, to reconstruct Nature constructing, to make anew for himself psychically, what has been made pampsychically. If I can, I am in the present case to penetrate to the generative cosmical Soul of Matter, and formulate its process in this its speculative sphere, which will be seen running through and shaping all the order which follows. In this elemental Cosmos we catch the first cosmical principles; we are to see the Cosmos thinking itself in its own primal categories, which we are to think after it and to formulate in our own linguistic way. Properly we are re-thinking Nature's thought and expressing it in impenetrability, gravity, inertia; these are really her utterances of herself, not simply mine; I am only trying to re-state in my dialect what she has told me in her dialect.

The opposition between Motion and Matter is the thread on which are strung all the forms of

Nature's evolution. Motion, the separating, tries to get fully inside of Matter, the separated, and to make it self-separating and self-returning, which would be the Ego. In the revolution of the Earth around the Sun we reach the supreme cosmical fact: Motion has gotten control of a material body from the outside, and is continually bringing it back to its starting-point while driving it forward. Thus Motion shows its deepest character to be cyclical and whirls matter along in its circuit never-ending. This control Matter in its way resists, though it too strives to get back to its source, as we see in gravity. For Matter is heavy and pushes for something beyond itself, appetent for aught which it is not. It tries to move of itself, though resisting Motion from the outside. Matter, therefore, manifests the original separation from the All-Ego, and even strives to return to the creative, primordial fountain of its being. Matter as heavy reveals its supreme estrangement, and is ceaselessly craving, is hungry for restoration. We often say of this piece of Matter before us that it seeks the center of the Earth; but if it really got there as material, it would still plunge with the Earth toward the new center in the Sun, which is itself seemingly on the way toward the center of the total Cosmos. And even the Cosmos is striving somehow to return like this lump of mud. Return to what? We may note here that physical Science does not attempt to answer this question,

deeming the same outside of its sphere. And yet this is ultimately the main point at issue.

It can be stated that Matter will stay through the whole domain of Nature with its appetency unappeased; it can never get back to its source except through Motion Egoized—the pure act of separation overcoming itself in an inner self-return. But that is a distant outlook, beyond Matter and beyond Nature.

And now we shall try to find the order in this abstract speculative Matter—elemental we call it, and it belongs to the Intellect (*Nous*) of the Cosmos, rather than to the sensuous manifestation thereof. The main point might be put in the question: What is the thought of Matter? Not merely what do I think it to be, but also what does it think itself to be. Of course Matter does not think self-consciously, and speak as I do, still it thinks and speaks in its own way, which I am to interpret if I can. Accordingly Matter reveals itself in a movement which can be expressed as follows.

(I). Its immanent character.

(II). Its qualitative character.

(III). Its quantitative character.

We have already designated Matter as the Separated in Nature, not indeed as moving and active, but as the fixed and passive. We can grasp the thought genetically in this way: Matter separated from the All is separated from itself, for it be-

longs to the All. The universe must have separation as material within it or as a part of it, else it would not be the universe. Matter is, therefore, always extended beyond itself, is separated from itself, having no self-return. Still it never fails to reveal its source and craves to get back; it strains to become one with its origin, and even with itself as Matter. These traits we are now to precipitate into the categories of Natural Science.

These categories of Matter, or at least some of them, have been questioned in recent science. It is claimed that Matter not only changes its form, but disintegrates and actually grows old and dies. We read of the dematerialization of Matter. Still the old conceptions hold their place in the Cosmos, though they are being shaken up in the Diacosmos. That is, while allowed in one sphere of Science, their place is challenged in another different sphere. But of this more is to come.

I. THE IMMANENT CHARACTER OF MATTER. Under this head we seek to give the primary fundamental characteristics of cosmical Matter. There are other characteristics, but they are not so compelling and innate, though they belong. I would set down that Matter is heavy as the essential property of it, its very soul manifesting its inborn character. Still this one characteristic stands not by itself, but suggest a process, which makes it explicit. This first process of Matter we can indicate in terms which have been already employed by physical science.

1. *Gravity.* Matter has Gravity, which is its ultimate determining principle. Hence we put this down first, as the all-inclusive, though as yet undeveloped characteristic of this Matter, not simply *a* property but *the* property of it, that which makes it what it is. In it lies the potentiality of material forces, their reservoir which is soon to be tapped. I throw a ball up into the air, it falls of itself by Gravity, it is so much Gravity primordially as matter, whatever other qualities it may have. If we ask why it descends to the Earth, the answer is, through Gravity. But whence and what is Gravity? Surely it cannot be an isolated thing in the Universe.

It is to be observed in the first place that Matter craves to unite with the Earth, with the Sun, with all Matter, that is with itself, from which it is separated. This stress for unity finds its expression in Gravity. Nature is the heavy Universe, subject to Gravity, which means that every material body, yea every material particle seeks to get to the center and thereby to become self-centered. In this sense Gravity is said to cause Motion, though in the deeper primitive sense Motion causes it. Moreover the presupposition of Gravity is the antecedent separation of Matter, its estrangement from the self-centered Universe with which it eternally craves to be again united.

It is next to be observed that every cohesive body and every separated particle of Matter has

its own center known as center of Gravity, being endowed itself with the self-centering impulse. Moreover this center is a point, is merely posited as ideal or non-material, in strong contrast to its real extended Matter, whose dualism is thus manifested—its real outwardness spatially and its ideal inwardness in a center. Significant is the fact that if we divide Matter, each particle posits its own ideal center as if working after the pattern of the whole material Universe. Center of Gravity is this and belongs to every material body however minute, as well as to the great totality of Matter. Hence every piece of Matter has two extreme centers of Gravity, its own and that of the Cosmos, both of them unextended points of extension. Then it may have other intermediate centers.

Finally it may be remarked that if Matter manifests its desire for unity in Gravity, this desire remains without fulfillment. If it were fulfilled, that would be the end of Matter, for it would lose its soul which is Gravity. Separation of Matter has gone before Gravity and conditions it; there could be no craving for unity without the previous division. Unless Matter were repellent, and indeed repellent of itself, there could be no ground of its assertion of unity through Gravity. So we reach a new characteristic immanent in Matter—Repulsion. We can conceive the physical universe with its one center of Gravity divided in

innumerable centers of Gravity, down to the atom, each of which asserts itself, and so repels all the rest.

2. *Repulsion.* Matter has Repulsion which has been already indicated as the presupposition of Gravity. A body would not be heavy unless it were separated or repelled from the Earth. But the Earth also is Matter which is thus the self-repelled ere it can seek its unity by Gravity. Repulsion is immanent in Matter as extended.

On the other hand Repulsion follows Gravity as a result. Each particle of Matter has its own separate center of Gravity, its own individuality we may call it, which it must assert in order to be. From this point of view Matter is seen to be infinitely self-repellent; the whole Cosmos becomes the arena of material Repulsion. The ball indeed descends to the Earth, but is met at the limit and is repelled; neither can penetrate the other, or reach the other's center. So material objects, after seeking their unity through Gravity, and perchance flying toward each other in a common desire, reject one another with a kind of aversion. It was probably this aspect of things which induced the old Greek philosopher Empedocles to say that the Cosmos was the scene of an eternal war between Love and Hate. In the Solar System the planet seeks the center of the central body, being turned to it when farthest from it, and repelled when nearest to it. In the Heavens where Matter

moves free, without being stopped, it shows most plainly its dual character as center-seeking or self-seeking, and center-fleeing or self-repellent.

In the Cosmos as such, Repulsion works directly upon the cohesive body as entire, even if small, and moves it from the outside. But in the Diacosmos, or second grand sphere of Nature, Repulsion gets inside the body and tears its molecules asunder, especially through Heat, transforming the body and changing its character. And in Electricity will be found a more striking manifestation of the same fact.

All Nature has been called dialectical and naively self-contradictory; it cannot help denying itself, or repelling itself, we may say in this connection. Matter as separative thrusts itself from itself and therein is Repulsion. It is negative to itself as unity, and thus manifests a phase of self-negation, which indeed runs through all Nature as separated from the universal Self. The Ego too we may consider self-repellent, but it returns to itself out of Repulsion. If it had to stay there, it would be Matter.

Material bodies, excluding and repelling one another, manifest again a common principle, have indeed in their mutual exclusion found a new unity. In their very Repulsion they are held together by a universal law, and form a system of repellent bodies. The whole Cosmos becomes such a system. Repulsion as universal would destroy itself

by completely repelling itself and so getting rid of itself. Matter, therefore, through Repulsion unfolds into Attraction, a new sort of Gravity with a new desire for unity.

3. *Attraction, (Gravitation).* The law of the Attraction of Matter is usually deemed the greatest triumph of the Science of Nature. It is emphatically universal, holding true of the tiny particle before us as well of the remotest star. Already in Gravity Matter manifested Attraction, but this was not known to be universal, nor was it reduced to law except in portions. So a new word is added: Gravitation. The Attraction of Matter through Gravity pertains to the first implicit stage before-mentioned; the Attraction of Matter through Gravitation is this third explicit, legalized, universalized stage. The first has long been known and variously employed; the third is quite a recent acquisition of knowledge, and is coupled with the name of Sir Isaac Newton.

This law of Gravitation may be put together as follows:

All material bodies are mutually attracted, and so tend to move toward one another. They vary directly according to their masses, but inversely according to the square of their distances from one another.

The law which reigns over and organizes the system of cosmical Matter is now formulated. Through it the Cosmos is getting ordered more and more with the years. The schoolboy learns it

and applies it too; it has become a part of the consciousness of civilization. Thus stolid Matter, the repellent and self-repellent, has an obedience, and is drawn to the unity of Attraction even through Repulsion. It furnishes the most impressive and enduring object-lesson in the universality of law.

It may be here stated that there were two historic antecedents which unfolded into Newton's law of Gravitation. Galileo had already formulated the law of falling bodies on the Earth's surface, or the law of terrestrial Gravitation. Soon the question came up: does this law apply to celestial bodies also? The other historic antecedent of the law of Gravitation was the third law of Kepler (the square of the period of each planet is proportional to the cube of its mean distance from the Sun) which suggested to Newton and to other contemporary scientists, that the attraction between the earth and other planets might vary inversely as the square of their distances. But Newton first proved mathematically the truth of this supposition.

But before the law of Gravitation could be proved Newton had to establish another very important principle. This was that the Earth's attraction is not on its surface or distributed through its parts equally, but is concentrated in the center. So there is a center of Gravitation as well as a center of Gravity; the cosmical bodies, however large, have their attraction unified in a central

point. It is this ideal point of unity which draws all Matter and is drawn by it, in the physical universe. And this physical universe seemingly has its ideal center, attracting possibly our whole solar system centered in the Sun, which is declared to be sweeping with its planetary retinue toward the star Vega in the constellation of the Lyre.

Attraction and Repulsion are often called forces which determine Matter; but Matter really determines them. Nor are they to be regarded as independent forces dropping down from the outside, but they must be joined in a process together. Kant is said to have construed Matter out of Attraction and Repulsion: the better way is to construe Attraction and Repulsion out of Matter, which is their antecedent and is derived from a higher source. With Gravitation is also connected the troublesome problem of *actio in distans*, or, as it is usually stated, of a material body acting where it is not. Such action evidently runs counter to the mechanical view of the Cosmos.

Looking back at the immanent process of Matter with its three categories, we can observe that the Cosmos is through Gravity a scheme of Attraction, all parts for each; yet it is also a scheme of Repulsion, or the mutual aversion of these parts, each against all: then finally it is a system of Gravitation, in which Repulsion is overcome into Attraction. In their way these three categories reflect the three divisions of the Cosmos as con-

ceived in this book—that of elemental unity, that of particularized separation, and that of the systemic return to unity (seen in the Solar System). The dialectical thought of the present process is manifested especially in Repulsion, which, to be true to itself, must repel itself and thus undo itself, threby returning to unity in Attraction.

We should here add that weight or ponderability has not been considered by many thinkers and scientists a necessary and essential property of all Matter. Newton writes in the second edition of his Optics: "To prove that I have not considered weight as a universal property of bodies, I have" etc.—this would seem to mean that he questions the immanency of Gravity in material bodies. It was the *actio in distans* which troubled him, and which also drove Descartes to conjecture his subtle mediating fluid throughout the Cosmos. Still, Gravitation remains in all its force with its law, however its action may be accounted for.

Another claim of a recent scientist should be noticed: the separation between the ponderable and the imponderable has been made to disappear through the dematerialization of Matter, which can be visibly transformed into energy, or, as we conceive the fact, can be brought to exchange its cosmical for a diacosmical force—exchange Gravity for Electricity, to give an instance. The negative trend of to-day's physical science is thus characterized by one of its eminent devotees: "A certain

anarchy reigns in the domain of the natural sciences, no law appears rigidly necessary," not even the law of Gravitation. "The very principles of Mechanics are contested and recent facts shake our faith in the laws hitherto considered fundamental" (L. Poincaré). So along with the political, the scientific anarchist has arisen, and breaks with the established laws of Nature. And we hear the exultation: "Nothing is more favorable to progress than this anarchy" (Le Bon). These protests are at least to be recorded, as they indicate, even if negatively, the birth of a new sphere of Natural Science, of which a full account is to be taken later. The breach with Mechanics, or with the cosmical laws of Matter, is indeed significant, though such an assault cannot well succeed. Failure is pretty certain to bring the assailants out of their negative attitude into their positive field, which awaits them. In other words the true place for their world is not the Cosmos but the Diacosmos, whereof the exposition comes later. At present, then, we shall pass to considering another set of the transmitted categories of Matter.

II. The Qualitative Character of Matter. We seek to make a distinction between the immanent character of Matter and its qualitative character. Both are manifested in the so-called properties of Matter, which are usually recounted in the text-books one after the other with little or no connection or order. Attraction, Repulsion, and

Gravity are called properties of Matter, but they are immanent, and constitute Matter itself. On the other hand, Matter has certain derivative properties, which belong more to its manifestation, as density and elasticity, or that which we infer from its essence through reflection, as divisibility. Such properties must be deemed secondary and relative in comparison with the primary ones already given. Even the indestructibility of Matter can hardly be an immanent property of it immediately present to our senses like gravity; rather is it an inference of our reflection.

There are many properties of matter; these constitute indeed the sphere of its multiplicity. There is an indefinite play of them out of Matter, which the Mind names—ductility, malleability, liquidity, density, etc. All these we shall not attempt to list and order at the start, but take them as they arise in the course of the exposition. But there are three central ones which belong together in a process, and which may be deemed the core of the others.

1. *Impenetrability.* That Matter as such can not be penetrated has long been an axiom of Mechanics. It offers resistance, it asserts itself, it affirms its being against intruders and assailants. Or one piece of Matter excludes any other; the two cannot occupy the same space at the same time.

Still the nail penetrates the piece of wood by a displacement of particles; the sunbeam penetrates the

transparent window-pane, the X-ray penetrates the untransparent human body. So there is a kind of penetrability of Matter. But in the last resort the atom alone is said to be impenetrable, and again there is the refuge in an idea which is not ideal but material. On the other hand Matter as a stage of the universal self cannot be penetrated or assailed with success, being verily an integral part of the process of the All.

Logically penetrability contradicts the nature of Matter as external. Matter cannot penetrate Matter and be inside of it, for it is just the outside of itself as space-occupying or extended. If the outside becomes inside, it contradicts itself, since Matter thus is non-material. Properly then if Matter penetrates Matter, it still remains outside of itself in such penetration, it can only push itself aside or outside. Its separation cannot be reached; that is, Matter must remain the Separated, if it remains itself. So Matter is impenetrable by Matter in the sense of undoing its separation, but in the sense of separating it simply Matter is supremely penetrable, or divisible, by Matter. This is also asserted as a quality of Matter in the following.

2. *Divisibility.* This may be deemed a property opposite to the foregoing impenetrability, since to penetrate Matter means to divide it. Thus Matter, true to its dualistic character, is endowed with two contradictory qualities. The grain of musk,

scenting a room for years without apparent diminution, shows an enormous divisibility of a small bit of Matter, as a thing of sensuous experience. That musk is not only divisible, but seems self-divisible and indeed self-repellent, to one of the senses.

And yet divisibility is supposed to run upon its limit in the atom, which is usually, though not always, declared to be indivisible. An idea, or something beyond the senses, yet material, is once more the landing-place of Matter, now as divisible, which, however, has negated itself, has divided itself to indivisibility, and persists in being dual and self-opposed.

3. *Indestructibility*. If Matter were absolutely divisible, unable to resist division at the last stand, it might well be deemed destructible. The atom in some shape offers the final resistance to the negative might of separation. So we have another quality of Matter, indestructibility, which as a word, suggests the negation of destruction. Matter, then, has the power of overcoming its own destroying energy. Something of the same sort was hinted in impenetrability.

Matter changes form in numberless ways, but underneath all these changes it persists, both in quantity and quality. If it be indestructible, it cannot be increased or diminished in the Universe. The Solar System may be losing Matter, as it is said to be losing Motion and Energy. But the loss

in one place of the Cosmos is the gain in another. The amount of Matter is conceived to remain the same; sometimes it is said to have been created by fiat all at once and once for all. But really it is a stage of the universal Ego itself, not a demiurgic creation thereof from the outside. Matter with Motion is a necessary part of the process of the All-Self, which could not be without it. Hence it is the same whether regarded quantitatively or qualitatively. As a whole it must be of the same amount and of the same character. It is the Separated in Nature which is still the second act or stage in the process of the Pampsychosis. Hence we may say that Matter as well as Motion is indestructible, is as persistent and as necessary to the Universe as is Nature herself. For the All cannot be destroyed, else it were not the All.

Matter, therefore, is not destructible, it never has been and never will be destroyed. No particle of it has perished since the beginning, any more than God has perished. The amount is the same, though probably variable in spots; it may become more or less in different parts of the Cosmos. Hence the conception of its quantity rises to the surface, as distinct from its quality. Next this phase of its character is to be considered—the quantitative.

We should add that these qualitative categories of Matter have not escaped criticism in recent science, which is making many an assault upon the

older scientific structure. Their inner dualism has been set forth, often with a negative conclusion which does not necessarily follow. Especially the indestructibility of Matter has been questioned with no little intensity. Again we may repeat that this opposition springs from the Diacosmos and its scientific training, and must be considered in that sphere.

III. THE QUANTITATIVE CHARACTER OF MATTER. The conception of Quantity as pure or abstract has been already unfolded from Motion. In fact all the elements of Motion—Space, Time, as well as Quantity proper—show a quantitative character. They are not only measurable in themselves, but the primal condition of all measurement. Bodies are, first and foremost, in Space and Time, which must be conceived as existent before being filled with bodies.

Matter has, accordingly, a quantitative character; it is the Separated, and so it brings up the question, How much is it separated (Quantitas, How-muchness).

Evidently in the present stage of Matter—the quantitative—we are turned back upon Motion with its three elemental forms, Space, Time, Quantity. These are now realized (*res*, a thing), or we may say, materialized, being in pure Motion immaterial. On the other hand Matter as the Separated shares in these same forms and thus shares in Motion, as every law of moving Matter indi-

cates. Accordingly in the quantitative character of Matter we shall find the three stages, Matter as spatial, as temporal, and as the Quantum. Concerning these stages a word or two may be added.

1. *Matter quantifiable* (*spatial*). It has been already stated that Space is quantifiable, so also must Matter be, according to its genesis. Matter occupies Space, and gets a spatial character; it has extension with the potentiality of division. Matter, however, as the Separated has the fixed drawn limit in Space, which limit Space itself has not, being always outside of itself so that its limit is no limit. Thus Space offers no limit to Motion, while Matter does.

The quantitative character of Matter in its spatial aspect is, then, its quantifiability, its capacity of being quantified and measured. Motion is quantifiable through pure Space; Matter, through occupying Space, becomes quantifiable, being not yet active or quantifying, but at rest, unmoved, with the possibility of Motion which now begins.

2. *Matter quantifying* (*temporal*). In the process of Motion Time showed itself as the primal quantifying principle, dividing all continuity into moments of succession. Likewise Matter, sharing in Motion, is made temporal and quantifies. That is, moving Matter is always quantifying in Time, is getting fully measurable, for Time is an element in its measurement.

Moreover Matter, being in Time, is always changing, always arising and vanishing. The temporality of Matter is indicated by its perpetual metamorphosis, which, as is usually said, takes place in Time. Matter as spatial is the fixed and bounded, but this bound becomes fluid in Time, so that Motion at once starts to determine Matter.

So we are to see that Matter, in the ceaseless change of Time, is quantifying itself, is not merely quantifiable as in Space. The process of quantification is at work, is really in the middle stage, but not yet complete.

3. *Matter quantified (the material Quantum).* It is to be observed that we have already had the universal or elemental Quantum as a phase of pure Quantity, which unfolds also its unit of Measure in the most general sense of the term. But now we are to see the unit of Measure made specific, real, embodied. The child, spanning with its little hand, is using an embodied unit of Measure or Quantum, which, however, implies an instinctive idea of pure Quantity.

Matter as limited is always a Quantum. A piece of coal can be the unit of measure for a coal-mine, and the coal-mine itself is a unit of measure. All Matter is composed of Quanta. Man, through convenience or instinct, selects one of these as his material unit of Measure. But this he could not do unless the quantitative idea were in him, harmonious with that of Nature.

Matter, accordingly, as the Separated, gets this its final quantitative character (the material Quantum) when it is quantified after being quantifiable in Space and quantifying in Time. Thus Matter becomes measurable, which it is not simply as spatial or as temporal, not as Space-occupying here and there, or as Time-occupying in this moment and that. Matter when quantified means that its standard of measure has unfolded. This material Body occupies not only Space but so much Space (so many cubic inches, say), and occupies not only Time, but so much Time in changing from here to there (say so many minutes). The Quantum has appeared for measuring the Quantity, which is thus itself quantified. Great is the Quantum, it is the standard or unit of measure which specifies and realizes abstract Quantity.

Space may be deemed purely continuous Quantity, Time purely discrete Quantity; neither can be measured till the Quantum (the modulus, or determinate *How-much*) becomes the quantifier of these unquantified Quantities (quite as we must have the good deed to measure abstract goodness). And so the point has been reached that Matter has become quantified through its Quantum, measurable though itself as measurer.

We have now attained the conclusion of Matter as here set forth in its three leading phases—immanent, qualitative and quantitative. If we regard the immanent phase in the form of gravity

or repulsion or attraction, we find that they all must become quantitative, that they call for measurement. The Quantum thus goes back to them and quantifies them—which rounds out the present process of Matter. Newton measuring Gravitation with his Quantum suggests this whole process of Matter.

To be sure these categories of Matter seem not very material, yea perhaps not very intelligible in their subtle implications. We have indeed to think Matter, or rather to make it think itself in its own categories. These the scientist on the whole accepts as they are; often he is averse to dealing with them purely; he does not care to examine his mental tools, but his experimental apparatus cannot be neglected. Still the science of Nature must get back to all its pre-suppositions, if possible; especially of these categories it must seek the order, and must probe down to their ultimate psychical import. We can think in phenomena like Liebig, but we cannot stop there; we have at last to look after our thought thinking in phenomena. If we can find its basic process, we are getting hold of the last control of phenomenal Nature.

The quantitative character of Matter has completed its expression in the material Quantum, which is employed as the measurer of Matter. Evidently both the measured and the measurer are material. The next step is that both drop their

Matter and become immaterial; the measurer measures the measured purely in its own forms; or the Quantum in itself quantifies Quantity in itself, both being expressed in their own symbols which are now called mathematical. Thus we see Quantity getting a new body of its own, adequate and transparent in its processes. The Quantum now separates from its previous material embodiment, and turning back upon itself becomes self-measuring, and thus universal, for it can now measure itself and everything else.

This sphere we call Measure. Quantity, hitherto implicit in Matter and the incorporate soul thereof, gets explicit in its own right and unfolds into its own forms with its own process. To the eye of thought Matter dematerializes itself through its own necessity and brings forth immaterial Measure. We might also say that the inner principle of Matter throws off its outer encumbrance and evolves its own world of shapes, which, however, will show themselves as still controlling the material world. Matter we have seen to be inherently self-undoing, for instance through gravity; it craves somehow to get rid of itself, to separate from itself, being just the separated by its primal birthright. But when Matter has succeeded in separating from itself, it is no longer Matter, it has gotten out of itself and has become non-material, a disembodied ghost of itself. These dematerialized shapes of Matter, the souls thereof we may conceive them,

with all their subtle processes are organized in the science of Mathematics, which from this point of view can be seen having absolute rule over Matter, as soul over body. This function may be summed up as universal Measure, which term we shall employ as best for our purpose.

III.

Measure.

Some difficulty has been felt in getting a good title for this third stage of the elemental Cosmos, which stage, as here conceived, is correlative with Motion and Matter. We have before us Magnitude, but it is Magnitude not as real or material, which would properly belong to Matter. It is Magnitude measured, or rather made to measure itself, in its own forms or symbols, which are mathematical, as we see when numbers are applied to themselves, for instance in multiplication. Five times four is one pure Magnitude measuring off another. The algebraic formula $a+b$ is the unity of any two Magnitudes measured and expressed, yet is itself a Magnitude. Now this Magnitude, measuring itself or at least measured by itself in its own pure forms, we shall call Measure.

The standard or unit of Measure as real we have already noticed under Matter. The hand or foot is such a real unit of Measure which is applied to a real object. But measurement as universal

must at last be brought to measure itself. If it measures all things it must not fail to include itself in the universal measurement. What we call Measure in the present case has just this peculiarity: it becomes self-measuring, it is forever turning back upon itself with its measurements. When I say: one half of four is two, I am measuring one measurement by another and stating the resultant measurement (there are four halves in two wholes). As we shall see later, this is specially the field of pure Mathematics, which is Measure, or Magnitude measuring itself in its own terms.

It is true that the word Quantity is often used for the preceding word Measure. In that case we would have to say that Quantity now quantifies itself, makes itself its own content—which it does in the mathematical disciplines. Quantity as two numbers being given, they are still quantified by being added, subtracted, multiplied, divided. That is, Quantity is always turning back upon itself and quantifying itself anew, such is just its process. But we have already used the word Quantity in a different and more fundamental relation: as the third constituent fact of Motion along with Space and Time.

Perhaps it will avoid confusion if we set down in order the three quantitative phases which have already appeared in the present exposition. (1) Motion, we may recall, is the Separating of Nature,

and involves the conception of pure Quantity. That is, there arises with Motion the thought of the How-much, or of the extent of this separation. Such is the primordial idea of Quantity, which must exist before there can be any measurement. Nature must indeed be measurable, must have in it Quantity ere it is measured. (2) In Matter (as well as Motion) we find Quantity, but with certain new properties. Here we come upon a real or material unit of Measure as Quantum, which is applied to other material objects. An illustration is a yardstick measuring a piece of cloth. (3) But now this yardstick must be taken free of its material substrate and made universal; such is the pure unit of Measure, or rather Measure itself in the sense here used, which through its arithmetical numbers, algebraic symbols, and geometric figures has in it the principle of self-measurement.

Again we may use an illustration from Geometry. When I enclose a triangle in Space, I limit the same, quantify it, reduce it to a Quantum. But I do not yet measure it. When, however, I find the sum of the three angles to be two right angles, then I have measured it, I have quantified its original simple Quantity. It is no longer a mere Quantum embracing so much Space. Still further, this measured triangle is not merely measured and equated, but becomes itself a measurer, or a principle of measurement, measuring even the area of the circle.

Accordingly we consider Measure to be the third stage of the elemental Cosmos, of which it is an inherent necessary constituent. The Cosmos is always measuring. When it is said that light moves through 193,000 miles in a second, over so much Space in so much Time, this is a cosmical act of measurement, which remains the same. There is no change in the rate when the ray has traveled from a distant star; its stop is just so long and no longer, measured to the unit of Time. Man undoubtedly has to re-measure the Cosmos and formulate such measurement in his own terms; still the cosmical Measure has always gone in advance of him and given him the cue. The mathematician comes to Nature with his Measure, which is his science, having the certainty that it is her own also. The unembodied forms of Measure, which are mathematical, become incorporate in the Cosmos, and rule its Motion and Matter. Gravitation is a cosmical Measure (directly as to mass, inversely as to distance) which existed in bodies long before Newton formulated, even before man existed. Indeed this was peculiarly the gift of Newton, the cosmical gift of Measure, which seemed to be stamped upon his soul as upon the soul of the Cosmos.

Motion and Matter must, accordingly, have their third, which is Measure, in order to form the process of the elemental Cosmos. This process underlies many of the simplest expressions of our daily

life. When I say: the train moves forty miles an hour, the conception rests upon Motion, Matter, Measure; or a piece of moving Matter is measured—measured indeed in the science of Measure. But the train must first run at a certain speed, must measure itself in Motion actually, in the special case. Now it is this Measure, inherent in all Nature, which we seek to grasp not merely in the special case, but universally, as it is in itself. It thus becomes the pure form of itself, expressed in its own categories, and measuring itself first of all and not something else.

It is true that when this ideal Measure has unfolded itself in its own pure forms—in numbers, figures, symbols, which represent only its own processes—it is re-applied to the world outside of it; we can say it goes back and organizes Motion and Matter, making their original implicit Measure (or Quantity) explicit, and giving expression to their native but hitherto unuttered, or at least unordered, harmonies. Mathematics, which we may call the science of universal Measure, is easily cosmical, finding its most open field in the Cosmos. Certainly the Diacosmos is far less mathematical, though it too must have its measurements.

We shall find, then, that Measure is at first instinctive, as when the savage holds up the fingers of both hands in order to count ten days or ten moons. But that which he measures is already measured—the day or the moon—by the Cosmos

itself, and he is but expressing in his way that primal cosmical measurement. Plainly the savage has in him the instinct of Measure, but undeveloped and tied to material reality. With the ages, however, as he liberates himself, he will likewise liberate his enslaved sense of Measure, making it truly free, determined by itself through its own forms, not through those of external Matter. Then these pure forms of Measure will return to the real forms of Matter, out of which they have evolved, and utter anew its measured essence or its innate quantitative character. Such is the movement: Measure, first manifested in immediate unity with the material world, must separate itself therefrom, and make its own world (the mathematical), whence it will go back to Motion and Matter, expressing their essence anew, and even re-constituting them after its ideal pattern. Measure is not only to re-state but to re-create the Cosmos; at least that is the start it is making here on our terrestrial sphere, which is relatively small enough.

It will be seen from the foregoing that the elemental Cosmos is a psychical process; its elements—Motion, Matter, Measure—as here conceived, form a Psychosis. Therein it bears the impress of its creative source, and is brought into unity with the universe. We call the All-Self great, it not only has magnitude but is magnitude, yea the first magnitude, fountain of all the rest. The Pampsychosis, begetting Nature as one of its stages, imparts to

its child its own process, which is its spirit, and which is re-enacted in all of Nature's processes, though deeply separated from their origin.

And now we are to observe that this Measure, though the third part in a greater movement, has nevertheless a complete movement within itself, still psychical and imaging the All. It has been already said that Measure is mathematical, and consequently it divides into the three basic disciplines of Mathematics: (I) Geometry, (II) Arithmetic, and (III) Algebra. Of course these do not exhaust the total science of Mathematics. They constitute, however, its germinal process, and as such have a very important place in pedagogy. Their psychical order should be specially considered, since it is often neglected or perverted in the school. The science of Quantity is usually given as the definition of Mathematics; note again that Quantity has to exist before there can be any science of it. And we may repeat that Mathematical science must be finally conceived as a part of Nature's science, as a stage of her scientific evolution. It is not something isolated, though in its sphere it is self-occupied, self-developing, self-measuring. Measure we have seen to return upon itself and to measure itself; still just that quality of it gives to it its place in the elemental Cosmos. The implicit Quantity of Motion and still more of Matter becomes explicit, no longer involved in something else but evolved in itself, having its own

self-evolution where the total evolution of Nature puts it. The three basic sciences of Measure we shall seek to give in their psychical order, to develop in themselves, and at the same time to trace certain lines of their interconnection.

I. GEOMETRY. This we shall place first in the order of the mathematical sciences, since it deals with the first elemental form of Nature—Space. Geometry cannot be the science of pure Space, an outline of which has been already given; nor is its object to investigate the properties of Space, as is sometimes said. The word itself has in it the category of Measure (*metron*) which is not to be left out. Geometry has to do with Space limited, determined, measured, dimensioned; not only is extension taken for granted, but also its dimensions —point, line, surface. Some geometricians begin their science with the conception of a solid "as a limited portion of Space" from which the foregoing three dimensions are to be abstracted. Says Legendre (perhaps getting a little antiquated): Geometry "has for its object the measurement of extension." So Measure turns back to Space already given, and measures it as limited or quantified. This again involves Quantity as something already given. Geometry, therefore, as the science of spatial Measure, must have in advance pure Space and pure Quantity, both of which we have seen to be elements of original Motion. The starting-point of Geometry is usually the form of limited or en-

closed Space called the angle, which is already Space quantified in the meeting of the two straight lines. Now it is this primal spatial Quantity which Geometry measures in the equation that "the two adjacent angles are equal to two right angles." This is properly the reduction of a great diversity of angles to a unit of Measure, the right angle, which is always the same. But this right angle is itself a Quantity (a How-much), which measures a Quantity (here of Space limited, but not yet measured). Again we observe that Measure is Quantity quantified, or turned back upon itself and quantifying itself.

It is evident that Quantity by itself cannot measure Motion or Matter, this can be done only by Quantity quantified. Motion unfolds Quantity at first as a stage of itself and so determines it; but Measure returns to Motion and determines it anew as measured. That is, Quantity must have quantified itself (as Measure) before it can quantify anything else. Geometry we have seen starting with this typical act of spatial self-quantification, which indeed makes it mathematical.

There is a decided evolutionary character in Geometry as a science. Given what it demands for a beginning, it has or can be made to have a very subtle yet ever-progressive development. Its propositions and even its figures evolve out of one another in a sort of creative order. It was probably Euclid who first introduced this evolution of

successive forms into the science, and thereby gave to it an extraordinary permanence. In its way it is a kind of mathematical anticipation and prophecy of Darwin. In the two men we may put together the evolution of space-forms as the first and most abstract stage of Nature, and the evolution of life-forms as the latest and most concrete stage of Nature. On this evolutionary side, even in the way of exposition, Geometry still awaits important triumphs.

We are to see distinctly what Geometry assumes in order to get a start. Three kinds of pre-suppositions it makes. First of all, it takes for granted Space and the spatial dimensions; secondly, it quite unconsciously assumes pure Quantity; thirdly, it more or less consciously acknowledges antecedent axioms, definitions, postulates. Of course the inquiring mind will ask, whence come all these assumptions? It is not the place of Geometry to tell, a science more universal must do that, perchance a complete science of Nature. And yet Nature also is something given, which can hardly tell its own origin. In like manner biological evolution is compelled to assume life and to unfold that from its faintest germ. It is generally agreed by scientists that no animate thing has been derived chemically or otherwise from an inanimate object. Thus Nature as scientific is as yet evolutionary only in fragments. The geometric fragment is one, seemingly the first one having a considerable

continuity. The biological fragment is another, the most recent and truly epoch-making, as it has made evolution the conscious end of total Nature.

The divisions of Geometry can be made from various points of view. As the Space-limiting line is fundamental in this science—it usually starts with two given lines—its divisions may be taken from the three kinds of lines—straight, curved, circular. The transition from the rectilineal figure to the curvilineal has always been one of the pivotal turns in Geometry. Indeed one cannot exactly pass into the other without a dividing chasm which may indeed be made very small, but which always remains. The straight diameter refuses to measure its own circle exactly—they insist upon staying separate, though the computation has been carried up to 707 places by William Shanks (in 1873). Of course such a long row of figures is totally intractable and indeed unreadable. Still the gap remains at the end, and is impassable. In like manner the quadrature of the circle shows the same impassable gap. The transition from the inscribed polygon to the circumference has always to take a last leap from straight to round after even "infinite subdivision" (significantly called "the process of exhaustion" by the old Greek sophist Antiphon, who is said to have introduced it into Geometry, where it still is found).

If the straight line has to be endowed with infinite divisibility in order to bend it into the curve,

what becomes of it when infinitely protended? Again the straight line is made to contradict itself, for it is by nature finite, limited, a geometric quantum. When divided to infinity or when produced to infinity, it seems to recoil and to make great geometric trouble. So it comes that Euclid's definition of parallel straight lines as those "which never meet, however far produced in both directions," has been the center of much discussion. For the question comes up: What if they be infinitely produced, extended with Space itself? And what if Space is also curved, is spheroidal as well as homaloidal or flat, as Euclid tacitly assumes it? At this point the socalled new Geometry rises to view, evoking for science a new Space, or at least a new conception of Space, which is no longer to be of the one homogeneous invariable kind hitherto accepted, but is of several kinds. Such is the modern struggle to burst the old spatial bounds of Geometry fixed so firmly by Greek Euclid (say about 300 B. C.). Even if it be merely an anarchic protest against the ancient order (as some declare), it is of great interest as intimating the sphericity of Space, which we have seen to be the primal elemental potentiality of cosmical Motion (p. 52).

So Geometry has not only an inner evolution, which is to be shown in the explication of it as a science, but also a corresponding outer historical evolution in time, of which we may note the leading steps.

1. *Oriental Geometry.* This, in general, clung to the sensuous object. The name of the science as land-measure doubtless came from the Orient to the Greeks, from whom we have received it, and who ascribed its origin to old Egypt. The annual overflow of the Nile caused changes which required fresh surveys. The Ahmes papyrus (Egyptian) which is supposed to reach back at least to 2000 B. C. treats already of the quadrature of the circle, has a pretty correct proportion between diameter and circumference, and would seem to have known something of the Pythagorean theorem (that pertaining to the sides of the right-angled triangle). Probably not as an abstract universal proposition was the latter known, but the first and simplest concrete case of it, when the sides have the proportion of 5 (hypothenuse), 4 and 3. This special case must have been exemplified at an early time by laying square blocks of the same size, as children do at present.

Later Oriental Geometry went to the Orient from the Greeks, yet often left out the reasoned demonstration. Very suggestive in this regard is the proof given by the Hindoo Bhaskara of the Pythagorean theorem. He takes the square of the hypothenuse given by a figure, and in this square he draws four right-angled triangles, between which appears a small square which, united with the square made up of the four triangles, fills the aforesaid square of the hypothenuse (see the

figure in Cajori, *Hist. El. Math.*, p. 123). Purely sensuous proof is this, one might call it a kindergarten demonstration. There was quite a development of Arabian Geometry in the Middle Ages, but this also was hardly more than an adaptation of Greek works whose science, however, the Arabians principally have the merit of having preserved and transmitted.

2. *Greek Geometry.* In passing from the Orient to Hellas, Geometry becomes truly a science. It unfolds out of its immediate sensuous embodiment into its abstract conception, rising from the particular case to the universal principle. If the ancient Egyptian knew one special example of the Pythagorean theorem, and the later Hindoo could prove it only to the sense of sight, the Greek rises to thinking it universally, and formulating it thus in his speech. He separates Geometry from its entanglement in material particulars, and makes it the pure explication and measurement of itself. It is no longer some empirical rule or set of rules to mete out some external thing, but it is a science meting out itself. We thus see it to be a stage of Measure which turns upon itself and measures itself. Let us again illustrate by that pivotal theorem still named after Greek Pythagoras: the square of the hypothenuse of a right-angled triangle is equal to the sum of the squares of the other two sides. In this equation we see one geometric form or concept measuring another geometric form or

concept, performing an addition also, we may say. Measure can here be observed measuring itself. Or Quantity is again seen quantifying itself—now a geometric Quantity, namely a square, which is the unit of Measure. This is an example of just what the Greek did: he seized the geometric science of Measure, freed it from its material clog, and turned it back upon itself, making it measure itself. Then Geometry became scientific, being divested of its Oriental submergence in the forms of the particular.

It may be briefly premised that there was a similar movement from the Orient to Greece along the whole line of science. Philosophy goes the same way, seeking for the first time to grasp and formulate "the essence of being" in its own pure thought and categories. Now it is a striking and very significant fact that the first noted Greek geometer was also the first Greek philosopher, Thales of Miletus. He is reported to have gone to Egypt for study and soon to have surpassed his Oriental masters, Greek that he was, and also an undoubted genius. Plutarch recounts how he astonished the Egyptian king, Amasis, by calculating the heights of the pyramids from their shadows, these being proportional to the shadow of his walking-stick, which could easily be measured. Quite a number of geometric theorems are ascribed to Thales by an ancient historian of Geometry, Eudemus, a pupil of Aristotle. From an earlier authority, the

historian Herodotus, we learn that Thales knew of the natúre of eclipses. His geometric work seems to have dealt chiefly with lines and angles; thus it recalls the first propositions of our present Geometry. Such must have been indeed the start of the science.

Pythagoras, also a philosopner, is another great name in early Greek Geometry. He too visited Egypt, and possibly Babylon, making in person the transition out of the Orient to Greece. His greatest and most lasting deed is that he founded a school and made Geometry (and Mathematics generally) an educational discipline, which it remains to this day. Pythagoras seems to have been the first actual schoolmaster, and the curriculum of his school has been unfolded but not superseded. Various geometric propositions are ascribed to him and to his pupils, from whom the master cannot be separated even by the lapse of centuries. Already Aristòtle speaks of the Pythagoreans, rarely of Pythagoras. And the most unique, if not the most important proposition in Geometry, still bears his name. It has exercised a marvelous fascination in all ages upon the geometric mind, and the charm is not yet over if we may judge by the title of the following book: "Six and forty proofs of the Pythagorean theorem," (translated from Russian into German, 1880). Pythagoras is said to have sacrificed a hecatomb to the Gods in his joy over the discovery. What

method of proof he used is unknown, but probably the Greek as distinct from the Egyptian, which he must have learned in the land of the Nile. Some recent writers conjecture that his demonstration was similar to that of the Hindoo Bhaskara already cited. If so, then he had not fully made the transition from the Oriental to the Greek geometric consciousness. But such a view is very improbable, as it throws Pythagoras out of his place in the line of scientific evolution. And it is not pretended that there is any fact to support such an opinion.

Interesting is Hegel's view of the Pythagorean theorem, which he extols as the greatest of geometric theorems, being "an image of the Idea. It is a true totality, which has divided itself within itself, as every form in Philosophy is divided within itself as Conception and Reality" (*Phil. der Natur* s. 61). The side of Reality in the foregoing theorem is plain enough, but the side of Conception (*Begriff*) is what gives trouble. This Hegelian Conception is, in general, the process of universality, particularity and individuality, as set forth in the philosopher's Logic. But it is not obvious how the Pythagorean theorem manifests those three categories of Conception (in the Hegelian sense) and Hegel does not explain the difficulty. We may well think, however, that there is a triune psychical process lying at the basis of this theorem (and indeed of Mathematics generally). It starts with

the one (square), unfolds into the two (squares), which return and unite in equality with the first one (square). In such a statement we may note the process both arithmetically and geometrically. In this connection it may be added that Hegel makes Quantity a category of pure Logic (the second stage of Being), and not of Nature. Kant on the other hand places Quantity first on his list of the four general categories of the Understanding. Thus the great philosophers differ about the ordering of Quantity as about many other things. Hegel in his Logic has the merit of seeing the importance of Measure, which, however, he correlates directly with Quantity and Quality, designating it as quantitive Quality. As we regard it, Quantity evolves in and through Nature, and is to be co-ordinated in that sphere. To be sure, Quantity is psychical, or we may say, pampsychical; but so is Nature, one of whose stages it is in the cosmical order. But let us return to our geometrical sketch.

Plato's love of Geometry is well known; on account of its abstraction from the material world it appealed powerfully to the Greek idealist. Over the door of his Academy stood the famous inscription: "Let no one unacquainted with Geometry enter here." Seemingly it was his propedeutic for philosophy and also for ethics, the preparatory training to a vision of the supersensible Idea which was the Platonic principle.

But the greatest name in Greek Geometry, indeed in all Geometry, is that of Euclid of Alexandria (about 300 B.C.). Not much is known concerning his life, but he has left a text-book called the *Elements*, which still holds its place in geometrical instruction, though not without opposition. Some have thought that Geometry sprang ready-made from the brain of Euclid, but such was not the case. It was an evolution, even in Greece. Still Euclid did the greatest geometric act in all time. What was it? He organized the science previously disconnected; he established the geometric method of proof, though he probably did not discover it; he impressed upon Geometry that evolutionary character so significant of the future. He ordered the disjointed fragments into a grand totality, he was the Homer of Geometry, and for this reason his work has lasted like Homer's. In the medieval time he became an authority on his science, which was not to be called into question. At last a reaction began to appear, the human spirit felt itself fettered by Euclid's limitations, by his method, by his pre-suppositions. Various attempts arose to transcend him, and even to supplant him.

3. *Modern Geometry.* Such is the name which the new geometric movement or protest usually gives to itself. We also hear of the non-Euclidean Geometry in contrast with the Euclidean, which has been subjected in recent years to sharp crit-

icism. Pangeometry is likewise one of its designations. First of all the old conception of Space is challenged, as already stated. The Euclidean postulate of parallel lines is especially assailed. Even a new dimension of Space, the fourth, is affirmed by some disciples. On the whole the movement takes a strikingly revolutionary aspect. It seems to turn against the transmitted conception of Geometry with a vengeful, destructive spirit. Euclid, the ancient architect of the science, is disparaged in various ways, even is condemned as a bad reasoner. Some educators would banish his time-honored text-book from the schools, while others would restore its partially lost supremacy.

It is a curious fact that the chief opponent of the traditional Geometry hails from Russia. Nicholas Lobatchewsky's book, called "Geometrical Investigations," is declared by his fervent disciples to be the dawn of a new era in Geometry. "What Copernicus was to Ptolemy, that was Lobatchewsky to Euclid," says Professor Clifford. One cannot help thinking that here again is a Slavic voice of protest against the established European order in science, and perchance in civilization. The same voice can be heard in Russian music, literature, politics. To be sure other peoples show a similar tendency; the geometric nihilist is pretty much everywhere during these days, battering at the ancient structure of Euclid, which, however, does not lack stout defenders.

It should be noted that this modern Geometry turns back to the pre-suppositions of Euclid, testing and often denying the truth of what he took for granted. As yet the result seems to be largely negative. What will be the positive outcome? When the new Euclid appears and re-organizes the whole science, then we may be able to tell.

But now we must pass from the Measure of elemental Space or pure extension (which gives Geometry), to the Measure of elemental Time or pure succession (which gives Number) whose science is the following:

II. ARITHMETIC. The definition of Arithmetic, as generally given, is the science of number or of numbers—this plural is significant, since it suggests separation, multiplicity, the second place of the present process. In this definition two terms or concepts are explicitly assumed: science and numbers. Whence do they come? Arithmetic is one of the mathematical sciences, belonging to Measure, in which Quantity turns back and quantifies itself. So we have just seen it doing with Space and producing the science of Geometry. But at present Quantity manifests itself in a new form or in a new Quantum, namely in the abstract unit, or the *one*, the ground of arithmetical Measure. Now this quantitative limited one, just by virtue of its limit must have another one outside of it, indeed many ones or multiplicity. Thus dialectically we enter the realm of number and of

numbers, which must come primarily from Quantity.

It is usual to put Arithmetic before Geometry, and in the order of study the tyro begins commonly his mathematical drill with the properties of numbers rather than with the properties of spatial figures. Still this old way is being changed in the new education. The kindergarten places first in the hand of child geometric forms which he is to get acquainted with through play. This is the earliest human mastery of the external world organized in itself and made a part of the school. Thus the child grapples with the primal element of Nature, Space—here not pure Space, but Space limited, formed, measured, which it is to re-measure and indeed to re-form. That is the order of the Cosmos, and also the order of education. A great step in the deepening of pedagogical science it must be regarded when the geometrical act is made to precede the arithmetical in the training of the child-mind, when the concrete spatial form is presented to the young brain just beginning its cosmical conquest, before the abstract numerical unit, which properly comes afterwards, both in Nature and in Thought.

Arithmetic must, accordingly, be put second in the process of Measure, or in the basic mathematical Psychosis. Fundamentally it is separative, akin to the ever-separating Time, in contrast with the unseparative, indifferent, purely homogeneous

Space. Arithmetic takes at the start the unit as quantum, or the quantified one, which, however, must as limited repeat itself and become many ones, or numbers. Time likewise keeps forever dividing itself into a succession of moments, each of which is a separated unit when quantified. We have already seen how Quantity as such follows Time and quantifies the same (as it also quantifies Space) getting the unit generically which is the ultimate measurer of all things. Numbers, of which Arithmetic is called the science, are primarily discrete, successive, temporal we may say, keeping up the relation to Time. This arithmetical science, however, is numbers systemed, ordered, put into their own inner process. But whence comes this their process originally, and what puts them into the same? The question carries us back to that psychical impress which we have seen stamped upon Nature everywhere, ordering it and making it in all its details an integral part of the universe of science.

Thinkers have repeatedly connected Arithmetic, the second stage of the psychosis of Measure, with Time, which is also a second stage, namely of elemental Motion. Kant seems to hold that Time is the source of the concept of Measure. Time is a perennial creation of units in the form of temporal moments; these units when quantified and made purely abstract are relieved of their quality of Time. Thus they become pure quanta or nu-

merical ones, and are ready for Measure, or specially for Arithmetic, which takes numbers for granted, without deriving them. Its function is to apply numbers to numbers, in general to turn Number back upon itself and to make it measure itself in its own numerical terms. Simple addition is already such an act of Measure, if we scrutinize it carefully. We can hardly call Arithmetic the science of Time, though a great mathematician, Sir W. R. Hamilton, designated Algebra or universal Arithmetic "as the science of pure Time." But we might say that Arithmetic is based upon Time quantified—the temporal succession of moments being transformed by Quantity into abstract quanta or units. This discreteness of Time is likewise the primal source of all atomism. In like manner Geometry cannot be called the science of pure Space, but of Space limited, quantified, made into spatial quanta, conceived as geometrical figures. To be sure in Space the quantitative unit is suggested by the point, but there it is as yet only potential. To use terms already employed in this same connection, the spatial point is the unit as merely quantifiable, the temporal point with its succession is the unit quantifying, which becomes quantified or the quantitative one through Quantity itself. Such is the abstract quantum or numerical unit which is taken up by Arithmetic as a fundamental assumption.

Here it is to be noted that the first Arithmetic, like the first Geometry, inhered in sensuous things, from which it had to be separated and purified, being thereby transformed into a true mathematical science. The primitive man counts by concrete objects, not by abstract numbers; still less is he able to make these numbers measure themselves. But the pure number lies implicitly in his sensuous numeration by his fingers. Now this pure number is what he has to separate from its material embodiment, and to make it work in and through itself. Arithmetic as a science is the ideal number-world organized into a system which likewise has its own inner processes.

The total view of Arithmetic will embrace three great systemic phases of Number, which we may designate in advance as follows: First is to be considered the Germinal System of Number, its primal psychical conception. From this unfold, secondly, the Special Systems of Number, the manifold Number-Systems of the world (or numeraries). Finally we are to attain the Scientific System of Number, the organized science of Arithmetic, such as we know to-day, and such as civilized man has known and developed into its present stage.

1. *The Germinal System of Number.* In this caption we seek to indicate the first inner ideal form of the numerical System. Such a primordial form is made up of three and is triune; oneness

unfolds through duality to threeness which returns to oneness, constituting one process which is, however, threefold, else it could be no process. All other numbers are products, in fact repetitions of one or ones which are separated and thrown off by this germinal act of number-making. Already in Time we found even in the moment a thrill, a kind of oscillation which at least hinted from afar a return upon itself that made it one moment. The oscillating pendulum will bring to a striking manifestation outwardly this innate tendency of Time. But at present our task is to grasp the place and the import of this genetic process of Number which is verily its creative cell or the germ of its system.

Here, however, the thought may be expressed that such a genetic system of number is itself numbered, and at the same time numbers all genesis of every kind in the world. The Pampsychosis utters itself in number, yea in just the creative triune process of number. The Universe is arithmetical, but also Arithmetic is universal, its impress is on every process of Nature, which her science has to separate and to express in its own terms. To be sure the All is something else besides number, but it is number likewise, and has always to be numbered, especially in its processes, else a link is left out, yea just the interlinking of the great Totality is left out. Such a glimpse we may here take in advance· but now

we must turn back to our genetic trinity of number and see it generating its special science which is Arithmetic.

(*a*) The primal quantitative *one* or numerical unit we have to pick up again at this point, having previously found it in Quantity, which quantified it directly from Time or more remotely from Space. Now the first peculiarity of this numerical one is that it cannot stay with itself, but must become another in order to be distinctively itself. We cannot conceive of one without two, it is said; the mind cannot grasp unity without the contrast of separation. But the far deeper fact is that the mind is unity in itself along with separation; so is Nature, so is the Universe. Thus our quantitative one, in order to be this distinct primal unit, must have two, yea must beget two, or another one which is separate from itself. We do this subjectively; but number does this also, objectively, that is the one cannot be the first one as limited without the two which limits it numerically.

(*b*) This two is the primordial form and expression of all dualism, separation and division in the Universe. Undoubtedly we have often had already the psychical process and marked its stages numerically, but now its numbers, hitherto quite implicit, have become explicit and are realized in their own forms. The numerical twain is verily a far-reaching symbol, suggesting all separation, alienation, sin, being typically the very Deuce or

the Devil perchance. Still it belongs to man and Nature, to the Universe, yea to God Himself in any complete conception. And now we are to grasp it by itself as a pure number, which is the second act or stage of the simple numerical Psychosis. It is the one divided into the two ones, in order that the one may be. Without two one cannot be; but that is not the end of the process. The two goes back and unites with the one, forming a new number, three, which is also one and the result of uniting the two with the one. So we reach the numerical trinity.

(*c*) The number three has been celebrated by peoples of all times and of all stages of culture in proverb, in folk-lore, as well as in Religion and Philosophy. It probably has the best right to be called the sacred number of mankind, as that number which most helps humanity to conceive itself and its God. Numerically it reconciles the self-opposition of the two, and the outer opposition between the two and the one. The symbolism of numbers can be and often has been carried too far; but to say that they have no symbolism at all is an error in the opposite direction, an error which isolates them in the universe. They have their place in the great Totality, and participate in its movement; they too bear the impress and superscription of the Pampsychosis. The number three has a mediational effect even as external number; it rounds out the numerical pro-

cess and harmonizes the dualism of the same, making the return which unifies and completes what was before disunited and undeveloped.

The scientist is apt to ignore and even to scorn the far-reaching psychical import of number, branding such a view of it as vague rhapsody. With him, then, we shall go back and consider the purely arithmetical power of this first numerical process which has shown itself triune. The salient fact here is that the primal genetic principle of number is just this trinity. It is the source from which all other numbers arise and to which they are joined, being brought thereby into the one great numerical order. Four, for instance, would not have been without the antecedent three, which made it first a one and then a four, putting it into its place in the order. The same germinal process it is which creates and conjoins with itself all the succeeding numbers, from five to infinity. And it should be added that the aforesaid creative trinity of number becomes the numerical form of every process whatever, that of my Self as well as of the All-Self.

Let it be understood, however, that number does not create the psychical process, though it always numbers the same in the three stages thereof; on the contrary it is the psychical process which creates number, as we have seen in the preceding development. The Pampsychosis is itself threefold; it numbers itself in its creative

act and therein primordially creates number; indeed every psychical process in accord with its supreme origin must number itself. For this reason the recurrence of the triune stamp upon every process, large and small, is what marks its connection with the universal Self, and at least hints its origin from the same ultimate source.

Such we deem the germinal Process of Number, the original source of numerical genesis, the primal arithmetical trinity. But now we are to see how this realizes itself in the external sensuous world.

2. *The Realized Systems of Number.* There are divers numerical Systems derived from the objects of sense. The one trinal System, being germinal, unfolds into many outer shapes. But in clothing itself with phenomenality, the orig'nal threefold process of number assumes external forms which obscure it and often seem to contradict it. There are, for instance, the decimal, duodecimal and vigesimal Systems, which are outwardly taken from the sense-world, though their inner creative power is the numerical trinity. The result is a separation which has been variously designated as the dualism between essence and appearance, the one and the many, the ideal and the real. Human experience shapes a numerical System, but there must be something already shaping the act of experience. Man counts at first by external objects, but he must already have the psychic capacity to

count. And in this sphere also we shall observe the process.

The process has as its center the number-system, which ought to have a special name (it might be called the numerary, analogous to syllabary or even dictionary). It is the numerical round or cycle which always returns upon itself and repeats itself in order to go forward with its increments. Such a numerary is the decimal system—the numerical self-reduplicating machine of civilized man It is to be noted, however, that this numerary always has in it the trinal germinal process of number—it starts with the simple *one*, unfolds into multiplicity, and then returns to the one which embraces all, constituting thus the system.

Now this numerary (or System of Number) has its stages of expression which likewise show an historic as well as a psychical evolution. These are, first, the sensuous, *acted* numerary primarily expressed by action of human body; secondly, the *spoken* numerary, introducing the abstract words for number—numeration or counting; thirdly, the *written* numerary, often called notation, the system of symbols (symbolary). These important points we shall elaborate a little.

(*a*) The sensuous number-systems among primitive peoples have been manifold. The first is probably the quinal, taken from the five fingers of one hand. Then comes the system of both hands with their ten fingers which produce the

decimal system. The ten toes of the bare-footed savage may be joined with the ten fingers to produce the vigesimal system, of which many fragments exist in civilized tongues (*score* in English, *quatre-vingts* in French). Also a duodecimal system has left a fragment behind in the word *dozen*, and has been recently urged for adoption on several grounds. But the most surprising of all those systems is the sexagesimal, supposed to have been used by the ancient Babylonians who were great astronomers, and who are conjectured to have transmitted to us our time-divisions of the hour and minute into sixty parts each, and the six times sixty degrees of the circle. It is not hard to see that of these multitudinous number-systems the decimal is the ever-present and most practical counting-machine. Also this system is most suggestive of the inner germinal Process of Number, employing in its movement a one and then a two (in the two hands) and finally the unity of both when placed together—which we may consider the visible triune round of the decimal System. This systemic unity becomes visible also in the quinal System by means of the transverse thumb embracing the four extended fingers or the four *ones*. A hint of such a quinal symbolary has come down from old Egypt.

Other sensuous numeraries have been observed; indeed they embrace many gradations, from the little bundle of sticks of the savage to the com-

plicated counting-machine of civilized man. But the human mind as numerical must reach out to grasping and expressing number purely, as it is in itself—which brings us to the spoken numerary.

(*b*) The next psychical act is to separate the numerical concept from the sensuous embodiment and to voice it, to put it into the spoken word divested of its material form. Man counts with his two fingers long before he counts two by itself. It is mental progress when he can transform his concrete numbers into abstract numerals. The child should be trained to make this transition in the school. The numerical object-lesson is often kept up too long, and the pupil is stunted by not making the change when ready for it. The abstract counting of a hundred is the delight of children because it shows a new mastery, a step forward. Now they begin to control number, which previously eluded them, being hidden in its material mask. Some advanced peoples never fully reach abstract numeration. The Chinese count on their fingers up to 100,000, it is said. The classic Greeks and Romans never could dispense with their abacus in their more complex reckonings. To make number speak out in its own form is still quite an act of education, which some persons very imperfectly attain. Abstract numerals have their first system in the nine digits (to which zero ought to be added). By the way the

word *digit* comes from the Latin for finger, and thus suggests the original method of counting by objects. So we have seized upon a sensuous term in a foreign tongue and have made it abstract in our own tongue.

Suggestive is the fact that these digital names are radically alike in the Aryan tongues, and thus carry us back before the period of the dispersion of our Asiatic ancestry. The proto-Aryans evidently made the abstraction of the digits from their concrete embodiment, and gave to them their names, which still exist rooted literally in the speech of their descendants, forming our first spoken numerary.

(*c*) The spoken word or symbol for number is not enough, man must have the written sign also or symbol. Speech is indeed a social act, doubtless the first and greatest means of association and impartation. But it is limited spatially and temporally, being confined to the particular place and moment of the speaker. Such a limit must be transcended by limit-transcending man; the written symbol is to be borne over Space and down Time. In Arithmetic this is called Notation which deals generally with the system of number-signs.

In the present field also there are hints of a long evolution, following and indeed reflecting the movement of civilization. From ancient Egypt traces of a system of number-signs seem to have

come down in the form of short lines; for instance one, two and three are represented each by a corresponding number of vertical lines; then with four the line changes to horizontal (seemingly following a picture of the four fingers with the transverse thumb). Thus the first dimension of Space, the line, is taken as the first numerical form, and the curious fact is that this form still remains in our written sign for the number one. Here we again are reminded of a famous mathematical statement that any magnitude whatever can be represented by a line, which would thus be the primal quantitative sign, and historically was the basis of the earliest system of number-signs.

Next came a peculiar transition. The Egyptian, as is well known, employed picture-signs for writing, not alphabetic letters or sound-signs. We have to suppose that the first number-sign, the line, was a picture, probably, of an extended finger. But with time the alphabetic letter representing a vocal sound, not a material object, arose out of the picture-sign or hieroglyphic. This significant change began already in Egypt, but seems to have been completed in Phenicia, from which country it was transmitted to Greece and Rome. From these we have received our alphabet, or the system of sound-signs. But what concerns us now is that the old Greeks and Romans took these letters or sound-signs for number-signs also, and we likewise still have among us the Roman

numerals, employing them in certain relations. It is said that the Greeks had an older system of number-signs, (called the Attic or Herodianic) but changed (about 500 B. C.) to letters for numbers. This was a strange step backward in numerical evolution, and was probably the result of intercourse with Oriental peoples who employed such a system.

This Greco-Roman notation lasted into the Middle Ages, though it stood in the way of all numerical progress. It was probably what crushed the Greek in Arithmetic, for which he did so little, and diverted his mathematical genius into Geometry, for which he did so much. In the 12th century the new notation, called the Arabic, though it was Hindoo in origin, began to be employed in Europe. Thus number possesses again its distinctive signs, different from letters: Arithmetic has its own symbolic language and begins a new career. The Arabic (or Hindoo) numerals are endowed with a local value in a line of numbers; the letter has no such value, V is five wherever placed, but that is not the case with 5. The cipher also comes from India, being necessary in such a scheme of notation. The so-called Devanagari numerals (Hindoo) are nearly those which we use to-day under the name of Arabic. The medieval Arabians in the bloom of their civilization brought them from the East to the West.

Thus we observe a significant evolution of arithmetical notation, from the early picture-signs of numbers (Egyptian), through the letter-signs of numbers, (Greek and Roman), to the pure number-signs, as we know them at present. In one way the last goes back to the first which was not a letter-sign, but a special token for a number, though probably intended for a picture. With this new instrumentality the science of Arithmetic unfolds into its present state.

The development of numerical notation may be hinted in the following written number-forms: five, V, 5. The first is still spoken as well as written; but the other two are written only, are symbols. But the last (5) is the pure numerical symbol, having gotten rid of its double meaning as (V); now the free science of number can start. It is set down that the first text-book of Arithmetic proper known in the Greco-Roman world was by Nicomachus, of Gerasa, probably an Arabian with Greek and Hindoo culture (about 100 A. D.). His work was the arithmetical authority in Europe for a thousand years, indeed till the Arabic or Hindoo numerary supplanted it. The first printed Arithmetic of the Renaissance was Wagner's (Bamberg, 1482). Simon Stevin, of Bruges, (1548-1620) is famed as the introducer of decimals, in which the numerary is employed as a whole.

In general the numerary, like man himself, has to liberate itself from its various external shackles,

and to become a free system of number, which deals with itself purely, unfolds its own forms, and thus rises into a true mathematical science, which we may now look at specially.

3. *The Scientific System of Number.* This is the science of Arithmetic as we know it to-day, the latest phase of the evolution of number proper. It is a form of Measure, or of Quantity turning upon itself and measuring itself. Number is now seen working with itself and evolving itself, combining and dividing itself milliardfold. We may say it is measuring itself, applying its own forms to itself.

The basic numerical process which Arithmetic employs is the numerary, the self-returning round of digits or of elemental numbers. These with zero are ten, hence they are usually put together as the decimal system. This numerary is the creative process of number always going back to the beginning and moving through its stages, and then throwing out a new round of itself, that is, of ten. Note here again the underlying psychical process of unity, of separation or multiplicity, and then the return to unity in and through the total cycle of digits. That germinal Process as the image of the Psyche is fundamentally triune; but its second stage, being derived directly from external Nature with her multiplicity, is itself multiplex, not purely dual, and still images the many fingers of its sensuous origin. Evidently this second stage

of the arithmetical numerary in its divisive character corresponds deeply with all Nature, which is likewise a second stage, and infinitely divided, and divisible. Hence it can be and must be numbered, or measured by number. Here we may glimpse the fact that the Cosmos is arithmetical, and Arithmetic is cosmical. The numbering of the Universe is going on everywhere in science, because number is inherent in Nature, and must be gotten out of the same and expressed in its own numerical terms.

Arithmetic has had its historic evolution, starting far back in the Orient, passing through antiquity and coming down to the modern age. All these periods have left their impress upon the science of number as they have upon its notation. For example: It is a curious fact that the old classic world was not so arithmetical as the Orient, especially as the Hindoos, or as the moderns. This deficiency has been ascribed to the lack of an independent system of number-signs (like our Arabic numerals); the Greeks and Romans used letter-signs for numbers which were therefore always clogged with a foreign body in their free movement. The reason holds good; still the question comes up, Why did they not relieve their numerical system of its fetters? Ultimately we have to think that it lay not in their spirit to evolve in that way. The Greek was fundamentally an artist and was inclined to deal with concrete

shapes rather than with the abstraction of number. It was, however, a Greek, Pythagoras, who conceived number to be divine, making it the basic principle of the universe and specially cultivating it in his school. The Roman was too busily engaged in conquering and ruling the world to develop much on any scientific line. The classical scholar is well aware that the numbers, expressed of course by letters, in the Greek and Latin manuscripts, are very uncertain and very ambiguous. Significant is the fact that Geometry, dealing with spatial forms, was the mathematical favorite of the Greeks, whose instinctive form-sense was deeply gratified by it, but was much less attracted by the blank abstraction of number. And yet the Greek in philosophy and ethics showed a grandly creative power of abstraction, which, however, he always sought to embody anew in a form of its own.

The organized science of Arithmetic has a chief place in the school for its practical value; it also must be regarded as the child's first training to abstraction—an educative act of the highest importance, through which the individual repeats in his own development a pivotal step in the race's progress. Moreover Arithmetic has its profound psychical significance which can be brought home to the pupil by sympathetic instruction. Here we can give only a meager outline of the science.

(*a*) The fundamental process of Arithmetic lies

in the three earliest forms of it—addition, subtraction, and multiplication. In these we see the simple unification of numbers, their integral separation, and then their repeated unification (often designated as the performing of many additions). Multiplication is plainly to be taken as the third or self-returning stage of the first arithmetical process. By it number turns upon itself and multiplies itself and also goes back to addition.

(*b*) The basic divisive or separative process of Arithmetic is brought together in division, fractions, and decimals. Division is the separation of a number into parts of a given size. It is the reverse of multiplication but something more. To perform it requires both multiplication and subtraction, and sometimes a form of addition. The fraction proper makes division explicit by a method of notation which is digital, and with such broken or divided numbers all the elementary operations are performed. But the fraction becomes systemic in the decimal, which has ten (the decimal system as a whole) for its dividing principle, or some multiple of ten. The decimal system, accordingly, sweeps back and embraces in its process the digital principle of simple and fractional division, since its denominator employs ten multiplied by one or more tens. Thus the second or separative stage of elementary Arithmetic shows three forms of division, the simple or integral, the fractional and the systemic or decimal. Moreover, it mani-

fests a process within itself which is psychical in form, though wholly numerical in contents. The text-books of Arithmetic usually show these parts by distinct heading and treatment, but indicate little or no interconnection.

(*c*) The third and supreme process of Arithmetic is that in which the individual number keeps turning back upon itself, reduplicating itself by means of powers (in involution), deduplicating itself by extraction of roots (evolution), and finally becoming the power itself, the essence or *logos* of number ((logarithm). Multiplication has already shown us any number multiplied by any other number; but involution insists upon the same number self-involved or multiplied into itself a number of times, and "this number of times" becomes a new sort of number, telling how many involutions. Evolution in Arithmetic is the reversal of the preceding involution; the procedure undoes the power and goes back to the original number, the starting-point. Evidently involution and evolution are two separated halves of a cycle of the power of numbers; now this power is to be seized upon and unfolded in the logarithm, which is manifestly the third stage of the present arithmetical process, and indeed the culmination of Arithmetic, if it be not already a plunge into Algebra. We take the following statement from an honored mathematician: "All numbers are considered as the powers of some single given number,"

which thus becomes the base of a logarithmic sytem. Moreover, the logarithm of any given number is the exponent of that power of the base which is equal to the given number. It is manifest that we see here a return to involution; any number by its own self-involution can become any other number. The quantity representing the degree or amount of such self-involution is its logarithm. This may well be deemed a common bond interrelating all numbers, and associating them in a new cognate tie. The question, however, arises soon about the true base of the logarithm: What number is it? Very naturally ten was promptly hit upon, but not by Napier, the discoverer of logarithms (first published by him in a book of 1614). Not a single digit nor several digits, but the whole system itself, the total numerary, must be taken as the one best logarithmic base, this being the genetic principle of all other numbers, as already set forth. The systemic base for logarithms was due to Briggs, a contemporary of Napier, and completed the discovery.

It is evident that the logarithm seizes upon the involution or the self-return of number as its essence or deepest principle. This also brings to light its psychical ground, as well as its true place in the total arithmetical process. The logarithm goes back to the first elements of the science and makes a new addition and subtraction, as well as a new multiplication and division. These are all repro-

duced in their essence and enormously shortened by the logarithm. Laplace said that by means of it the astronomer doubled his days. Through the self-returning character inherent in it the logarithm seems to revolve, to image arithmetically the primordial motion of the Universe. The so-called logarithmic spiral is very suggestive not only mathematically but also cosmically. One cannot help thinking of the nebular spirals of the First Matter in the genesis of Solar Systems. In this final process of number we had the involution of number (the power), the evolution of number (the root), and now we may add the revolution of number (the logarithm). So Arithmetic may be supposed to wind up with showing us that Nature thinks in numbers also.

The logarithm very decidedly calls for Algebra which has been named (by Newton) universal Arithmetic, or Arithmetic universalized. Indeed the logarithm quite pushes number to its limit, making it in its whole system (by the Briggsian method) return upon itself and measure itself completely as number. Arithmetical Measure as a mathematical science (the second in our ordering) has now measured itself fully and thus rounded itself out. The logarithm has driven the particular number in all its processes to universalize itself, as far as this was possible with numerical notation. Moreover, the logarithm cannot be adequately accounted for except through alge-

braic methods. It is proved naturally by algebra, and thus has its sources in the next higher mathematical science, at which we must now cast a hasty glance.

III. ALGEBRA. The word comes from the Arabic, and the curious fact about it is that it means literally, according to the etymologists, *bone-setting*, a putting together of broken and disjointed parts. Metaphorically it came to signify "a science of redintegration and equation." This is, then, the original meaning of Algebra: a restoration from a divided and broken-up condition, a return out of separation, which certainly suggests the place of Algebra in the elementary mathematical process. It follows Arithmetic and indeed evolves out of the same, making it universal (in Newtonian phrase) from its previous numerical particularity. For Arithmetic compared to Algebra is a special or particular Measure with its corresponding number, which the algebraic symbol elevates into the representative of all number.

Far better is this conception of the science than that conveyed by the term *analysis*, which is often employed in European tongues, especially by professional mathematicians, to denote algebraic science. This has, undoubtedly, an analytic element, but its deepest character is to be a synthesis, as the original Arabic word suggests. De Morgan, the famous English mathematician, calls it "the calculus of succession," carrying it back to Time

as its elemental content. Such a conception is in line with Hamilton's designation of Algebra as "the science of pure Time." This puts chief stress upon its separative, analytic element, and would make it, in a psychical ordering, the second stage of the present mathematical process. With such a view, notwithstanding its high authority, the present book cannot fraternize; we believe it, moreover, to be contrary to Newton's brief but very pregnant definition of this science as "universal Arithmetic." As the third part or stage of Measure, accordingly, Algebra shows pure Quantity quantified anew, but not particularly as in Arithmetic, but universally.

It is a very suggestive fact that these three elementary mathematical sciences begin and develop together. Historically they seem to start in ancient Egypt, which had much use for Measure. An Egyptian papyrus in the Rhind collection of the British Museum, is considered the oldest known treatise on Mathematics. It is written in Hieratic, and its composition is placed somewhere about 2000 B. C. But it claims to be a compilation from older documents, which may reach back to 3000 B. C. Thus in accord with the Egyptian mind, it has already the authority of age. The name of the writer is also handed down—Ahmes, seemingly the first maker of a mathematical text-book, whose intellectual progeny has certainly not become extinct in the passing milleniums. Now the most

striking fact of this Ahmes papyrus is that it contains all three sciences of Measure—Geometry, Arithmetic, and Algebra—in their primal united state, just beginning to get a little differentiated apparently. It has the triangle, square, trapezoid circle, with attempts at their measurement, which introduces Arithmetic. Then in arithmetical form appears a problem with an unknown quantity, which has its symbol or representative called *hau*, similar to our x. Other symbols are introduced corresponding to plus and minus, along with the sign of equality. Surely here is the germinal act of Algebra tackling its basic problem of finding the quantitatively unknown from the known.

It has been supposed that there is some Algebra lurking in the *Elements* of Euclid (Book X). If this be so the illustrious Greek geometer has in his work all three mathematical disciplines—Geometry, Arithmetic, and Algebra. But not till Diophantus of Alexandria (died about 330 A. D.) is there any pronounced Greek algebraist. He put special stress upon the fact that minus multiplied by minus gives plus. In the realm of Algebra he beholds the negative negating itself, the thought of which had already been known in Greek philosophy. Still he by no means draws all the consequences involved in the negative sign, and his notation is very inadequate.

The Hindoos did much for Algebra, they recognized negative and also irrational quantities.

They were also aware of the double answer for quadratic equations. Some Occidental writers claim that "the learned Brahmins of Hindostan were the real inventors of Algebra" in its wide modern sense. The Arabians lay between Greece and Hindostan, and often fluctuated from one side to the other in their mathematical science as in other matters. Really they were mediators between these two extreme branches of the Aryan stock, the Greek and Hindoo, thus performing what seems to be a chief Semitic function in history. An Arabian mathematician of the ninth century by the name of Alchwarizmi has transmitted to us the word *Algebra*, and was a main channel through which the Hindoo knowledge of this science percolated into Medieval Europe. The development, however, was slow. The symbols had, as it were, to grow into completeness; the Arabians used none, but they described the processes, while the Hindoos and Greeks used a few. A pivotal man in the symbolization of Algebra was the Frenchman Vieta (1540-1603). He made the symbolic use of alphabetic letters a permanent possession of the science, though others before him had employed them occasionally by way of illustration. It was Descartes, however, who introduced the capital distinction between the first and last letters of the alphabet, making the former represent the known and the latter the unknown quantities (in his otherwise epoch-making

work on *Geometry*, 1637). To Descartes we owe the extraordinary prominence of x as the symbol of an unknown quantity, which, however, seems to be reaching far beyond its algebraic limits, and to be taken to represent the Great Unknown and indeed the Unknowable of certain philosophers.

It is of interest to observe that every important algebraic symbol shows an evolution through the ages, and gives often some little reflection of the movement of civilization itself. The process of the great and greatest lurks in the small and smallest, if it can only be discerned. Even the algebraic exponent has its considerable history and is still engaged in a struggle. The evolution of printed text-books of algebra probably begins with that of Rudolff in German (1525), and is going on at a lively rate to-day. But these matters we must drop here and give a brief outline of the general content of Algebra.

1. *The Algebraic Symbol.* The first fact about Algebra is that it demands and develops a new notation, different from its arithmetical source. First of all, what we mentally do in Arithmetic, such as adding and subtracting, we throw out of us in Algebra into a symbol, such as plus and minus. Thus what is implicit becomes explicit, or the inside is turned outside. Such is a primal psychical transition from Arithmetic to Algebra. The subjective process is realized, manifested, objectified. To be sure there exist various kinds of

symbols, but the present kind is not the artistic symbol, not the image in which the outer directly bespeaks the inner. Rather is it the sign whose form says naught of its meaning, which, therefore, has to be specially learned and fixed in the memory. The significance of the algebraic symbol is what must be first grasped in this new mathematical science. (On symbols generally see author's *Psychology and Psychosis* under the head of the Rational Symbol).

Moreover, it employs a system of symbols which we might call the symbolary of Algebra, analogous to the numerary of Arithmetic and the figurary of Geometry. Each of these sciences has its own system of signs (say a signary) by means of which its procedure takes place. The algebraic symbolary is composed of (*a*) alphabetic letters as the universal signs of particular quantities. This may be deemed a return to the letter used for quantity, not as particular but as universal; for instance the letter X does not now mean ten but any number. To the letters must be added a second set of symbols (*b*) which indicate arithmetical processes by outer signs, such as plus and minus. The culmination is (*c*) the sign of the equation, which takes two different algebraic quantities and declares their equality, the chief purpose being to find the unknown from the known quantity. The equation gives the entire algebraic process, starting with its symbolized

quantities which separate into two opposite kinds, unknown and known, constituting the stage of separation. The algebraic act, however, reduces this two to one, it finds the value of x, it makes the unknown a known, so that the original separation between known and unknown no longer exists. All Algebra turns on the equation as its pivotal process; in fact it becomes in itself as a whole a symbol of science, whose chief function is to unfold the known out of the unknown. The equation gets explicit in Algebra, we may say, although it lies in the very first proposition of Geometry; but it is there not universally symbolized. The arithmetical process also is for the most part an equation not yet fully equated. From this point of view we can see that the algebraic equation expresses universally in its symbols the mathematical process in all its forms—geometrical, arithmetical, as well as algebraic. But in order to do this completely, the symbol must conjoin with itself the number.

2. *The Algebraic Symbol Numbered.* As the symbols of Algebra become many or numerous, they cannot exclude number from their process as universal; if they did it would not be universal. So Algebra takes up Arithmetic into itself, the symbolary unites with itself the numerary, and there results a kind of dual mathematical science. The conjunction of the symbol and number may be (a) immediate, composed of both equally, as

we see in 2x for instance. But the deeper fact is that Algebra takes up into itself and employs in all their potency the several arithmetical processes (*b*), such as the additive, the divisive, and the fractional. But when it comes to the extraction of roots (*c*), the arithmetical process stops, and can only be symbolized algebraically (for instance the square root of minus four). Evidently now the symbol wholly determines the number, while in the previous stage each retained its own distinct validity. Arithmetic, therefore, in its peculiar field, that of number, runs upon its limit in getting the root of certain quantities, that is, in returning to its numerical source. In order to accomplish such return, Arithmetic has to appeal to Algebra, which, as universal can overcome the arithmetical limit by its symbol. And in the logarithm, Arithmetic is hardly able to prove its own process, but looks to Algebra for its complete justification.

Likewise in Geometry arithmetical proof is single, special, not universal, and so has to reach out to algebraic proof for final anchorage. For instance the Pythagorean geometrical theorem is easily provable by arithmetic, if the sides of the triangle are respectively 3, 4, and 5; in fact this proof was probably known to the old Egyptians (see preceding p. 124); but such proof is of course particular, not universal. Now when the algebraic symbols with their explicit equation are in-

troduced to express this theorem (for instance, *a* square plus *b* square equals *c* square) we behold not only the arithmetical statement, but Geometry itself, unversalized in Algebra. This brings us into a new phase of algebraic development—the geometric. In this connection may be cited the statement of a distinguished mathematician: "All possible triangles, plane and spherical, and all their properties are expressed in the single equation $r=pq$"—which statement shows the geometric turned algebraic. The triangle with its three self-returning lines may be deemed the primal complete quantification of space, hence of all Nature, though it presupposes the single line as quantum. The first whole figure of Geometry, in the foregoing equation, goes over into an algebraic formula, which indicates a new sphere.

3. *The Algebra of Geometry.* In the present stage we find Algebra going back to Geometry, taking up the same into itself and symbolizing it anew. Thus this whole sphere might be called geometric Algebra, as the preceding one was dominantly an arithmetical Algebra. Plainly our mathematical science in and through Algebra returns upon itself, taking up its first form which was Geometry, and therein completing its mathematical (and also its psychical) round. This return of Algebra to Geometry is, in general, the finishing act of the process of elementary Mathematics

(Geometry, Arithmetic, Algebra), the Psychosis of these three sciences.

This resumption of Geometry into Algebra takes place in different ways, of which we may note the following:

(*a*) There is the immediate transformation of a geometric theorem into an algebraic equation, an example of which has been already given in the Pythagorean theorem. (*b*) Far deeper and completer is the algebraizing of Geometry in what is known as Analytical Geometry, chiefly through the so-called co-ordinate, which, starting as a line, becomes a kind of bridge over from geometrical to algebraic processes. This was one of the greatest as well as most lasting mathematical deeds of Descartes (first published in his Geometry of 1637). Here can be repeated the statement that the line as the first limitation of Space may be regarded as the first mathematical quantity, and as the primordial source not only of Geometry, but of all the sciences of Measure or of Mathematics. So Algebra universalizes Geometry, as it does Arithmetic also. But the curious fact springs up before the psychical student that it has gotten back to itself, and we observe Algebra in a manner trying to universalize itself, already supposed to be the great universalizer of finite quantities or forms of Measure (*c*). The Calculus we may, in general, call this highest sphere of Algebra and indeed of all Mathematics. From good authority we learn

that the Calculus as a whole treats of a "great variety of problems by means of some system of algebraic notation." There are many kinds of Calculus, yea, many kinds of algebraic symbolization. The start was made by Leibniz in his differential Calculus, very similar to Newton's Fluxions; indeed both these great mathematicians evolved the same science about the same time, and their friends have disputed over the question of priority ever since. From this beginning the Calculus has unfolded into many other forms, and its present condition seems to be that of variety, separation, almost disorganization—the whole of it lying around rather loosely in disconnected parts. It would appear that the mathematical genius has not yet arisen who can bring together into an organic totality its manifold disjointed portions. Psychically significant is the so-called Calculus of Operations, which is "the general method of treating quantities by operating algebraically upon the symbols of operation." Very suggestive is such a statement; it seems to indicate that the Calculus may yet develop its own symbolary, or the symbolary of all symbolaries, including doubtless the algebraic. At any rate Algebra on this side leads up into the sphere known as the Higher Mathematics, which must be deemed to be still in a state of active evolution.

We may, then, catch a glimpse of a universal science of Mathematics, to which Algebra, as uni-

versal Arithmetic and Geometry, is leading. At the same time the Calculus as the science of Measure pushed to the highest, is driven to grapple with the Infinite, which it, if it be truly universal, must also measure. The struggle between the limited and the unlimited in Quantity is strongly shown by the so-called infinite series, which is not infinite, but rather an infinite straining for the same. Can the unlimited be measured by the limited? It must, but cannot. So is laid bare the contradiction inherent in Measure or Mathematics, in all Quantity, yea in all Nature—a striving to be what it cannot, and if it could, it would not be at all. Mathematics as the science of Measure or the return of Quantity upon itself breaks down in the series, which will no longer allow such return, and so will not suffer Measure. This is only saying that Quantity is not the completely self-returning Ego or Consciousness, but is pushing for the same as its supreme end. Moreover the infinitely small is said to be negligible in Mathematics, but in thought it cannot be jumped over, being infinite. And this is not the sole difficulty here; the infinitely small cannot be smaller, and thus is a magnitude which cannot be diminished, and which therein denies its own definition as "that which can be increased or diminished." The same contradiction rises in the conception of a magnitude which is infinitely large. Evidently Magnitude, Measure, Quantity, have now reached

the point at which they show their inner dialectical character in a final self-undoing. Therein the elemental Cosmos has evidently reached its limit; it has attempted to measure the infinite and cannot, the incommensurable is just what it has found and of course recoils from. Measure can only measure the Cosmos as finite or particularized, and proceeds at once to do that—which statement suggests the content of our coming Chapter.

We are to see, therefore, that Motion, Matter, and Measure as cosmical run upon a breach between the limited and the unlimited, which breach lies in the Cosmos itself, is indeed the ground of what we have so often called its Dialectic. The inherent dualism of Motion was long since declared by ancient Zeno, as already stated. Matter cannot help reaching down to the atom with its dual character of division and indivisibility, bringing to the surface also the contradiction between the material and immaterial, or between the sensisible and the supersensible. And now we have seen Measure advancing to the chasm between the measured and the immeasurable—at which point it of necessity turns back and measures what it can—the limited realm of Motion and Matter, or the particularized Cosmos.

So the world, or what we usually call such, is now to be investigated, tested, quantified, giving birth to a very important part of the science of

Mechanics. We may look back to its beginning in Space, which contains the primal quantity, a simple line, and this line can be unfolded into the primal geometric quantity, a triangle, which is the first linear self-return. Thus Nature commences to be measured, in which work Science is still deeply engaged. Over and over again we have enforced the thought that Nature herself is quantitative, that Quantity is a part or stage of the Cosmos, that Measure is what may be called a Natural Science in the wide sense of the term. It is true that philosophers have disputed about the place of Mathematics in a System of the Universe. We can see, however, that there can be no Measure till the Separated (Nature) has appeared, bringing with it inherently the problem of the How-much (Quantitas), out of which Mathematics develop.

Repeatedly in the preceding exposition allusion has been made to the particular sense-world, from which indeed Measure is evolved and abstracted, thus becoming the science of pure Mathematics. Into the foreground is now to be drawn this realm of Nature, particular, corporeal, full of conflicts, with the search for its law and its origin.

CHAPTER SECOND.

THE PARTICULARIZED COSMOS.

We are entering the distinctive realm of Newton, and so we may imagine ourselves lying under his famous apple-tree and seeing the apple fall again. We note specially the two bodies, the earth and the apple, though there are many other bodies around us. Newton accepted the two as given, he seemed not to ask how they became two, or whence arose the vast diversity of bodies. He took the immediate phenomenon before him, but in it he glimpsed a universal act of Nature, extending it to the moon and sun and planets. All separate bodies are drawing one another into a common center, striving to overcome their separation; but whence this original separation? The question undoubtedly occurred to Newton, but he dismissed it and its like curtly with a wave of the hand: *Non fingo hypotheses.* He had enough to do in dealing with the given phenomenal world and discovering its laws, or the universal ways in which it acts. That is, the corporeal particularized Cosmos was his particular field, in deepest rapport with his genius. Newton's soul we may think, was one with Nature's soul just in her present stage, not so much in her previous elemental stage. To be sure, he distinguished absolute Time, Space, and

Motion, from relative Time, Space, and Motion (see first scholium of the *Principia*); but really he turned from the hoary primeval shapes of the elemental Cosmos, to the more tractable finite forms of what we here call the Particularized Cosmos.

We have now to take a new large step in the Science of Nature, constituting a very significant transition—the Cosmos incorporating itself in material bodies. Scattered throughout the physical universe we observe these bodies, from the smallest particle to the vast suns and the vaster nebulae of the cosmical spaces—how did they get to be? First in order let us note that they are separated—trebly separated—from one another, in themselves atomically, and from the All of which they are indeed parts, but disjoined parts, each having its own distinct individuality, so to speak. We should mark with strong mental emphasis this primal separation, as if the one original totality of the Cosmos had been split up or exploded by a universal convulsion into fragments which are still seen in the least and in the largest floating through the celestial regions. At present it is these fragments of the primeval separation which are to be considered, and which, taken together, we call the Particularized Cosmos, that is, the Cosmos reduced to parts and particles, divided into bodies—otherwise the Cosmos incorporate.

In the previous Chapter, which dealt with the Elemental Cosmos, these bodies were not yet born,

the convulsion had not yet taken place, if we may so conceive it. There we dealt with Motion, Matter, and Measure as not yet incorporate, but rather as ideal and speculative, though their existence was not denied. The elements of the Cosmos are universal and underlie all Nature; they constitute her original creative thought which the explorer of her depths has to re-think, and, as it were, recreate in his own mind. Motion, Matter and Measure have a decided supersensible strain in them, which is now to become sensible in the corporeal or particularized Cosmos. Here is the point at which the scientist ordinarily begins; he starts with the sensible object upon which he makes his experiments, leaving Space, Time, Motion, Matter, and Quantity, as original and elemental, to the metaphysician. But certainly the two sides or rather the two stages of Nature cannot be torn asunder without injury to both. Now we are to see the universal ideal element of Nature becoming particularized, real, embodied, accessible directly to the senses, at least in its finite relations. Indeed the finite world of Motion and Matter with their special measurements appears, revealing itself in phenomena with which physical science first grapples.

A necessary consequence of such a world of particular bodies moving and at rest (relatively) is their collision. They are in a mighty struggle and cannot help jostling one another. They belong

together and are striving to be one, for instance by attraction; still they are separated and must remain so in order to be. Hence their push for unity is always whelming them into conflict; the attraction is met with repulsion. A stone tossed from the hand seeks oneness with the earth, but collides with the same at their corporeal limits. Here is their original line of separation which they cannot directly overcome. Both stone and earth we may conceive to be fragments of that primeval, age-long, ever-continuing explosion of the All, which begot them as distinct individual bodies. They show themselves still to be parts of the one universe by gravitating towards each other without cessation, and yet they cannot get rid of that explosion which separated them, making them particular bodies. Thus we behold a colliding Cosmos in sharp contrast with the elemental Cosmos from which it has issued. Motion and Matter are changed from their absolute aspect and finitized in special forms, which, being measured in their finite relations, are brought into the fold of science.

The observation of the particularized Cosmos as colliding is largely confined to the earth. We may well suppose that there must be attraction and repulsion with the impact of bodies on the other planets. Thus each of them becomes a center of the clashing of Matter similar to what we see before us. How heavy a terrestrial body of a cer-

tain weight would be on small Venus and on large Jupiter has been often calculated. But it cannot be weighed directly by us except upon our own planetary surface. So the Cosmos now turns earthward and becomes a scene of conflict; bodies push, collide, fall together in a crash. We shall see later (in the Systemic Cosmos) that bodies of the Solar System with their circular movement have the tendency to avoid collision; they do not impinge upon their central sun, nor upon one another; the terrestrial conflicts seem to be harmonized in the celestial order. Aerolites are declared to fall into the sun, and a planet may now and then have to plow through the tail of a comet; still on the whole the arena of the heavenly bodies is not one of strife but of harmony—the ancient much-sung harmony of the spheres. On the other hand the terrestrial or perchance the planetary Cosmos is the scene of infinite collisions between material forms, which drive against one another more or less directly; their motion is generally interfered with and is not rounded out into the self-returning circle, as we observe everywhere in the free intermundane spaces. Such a colliding character belongs to the present stage of the Cosmos as particularized into a vast hurly-burly of struggling bodies, each striving to get to the center, and elbowing its neighbors out of the way.

We are, however, to emphasize the fact that the Cosmos as such has now gotten body or rather

many bodies—the grand manifestation of its separative stage. The elemental Cosmos is not yet incorporate, at least not to the human senses; if there is a material ether filling all Space, it is not directly apparent to us. This getting of body will persist through the entire development of Nature to the end. We shall have to deal with body not only in the rest of the Cosmos, but in the Diacosmos having its radiant body, and in the Biocosmos which has as its center the living, self-moving body. Great is this incorporation of the Cosmos truly sprung of the All, which therein gets manifested and has reality. To be sure these bodies are born in a struggle and reveal a vast conflict of forces which man is to master and to direct to his purpose when he finds their law.

And now we are to search for the order, yea the process in this realm of manifold collisions between moving bodies. On the outside it looks rather chaotic, as if it might be governed by accident; but we shall find that it has its laws, under whose power it has to act. From this point of view the particularized Cosmos with its struggling fragments fixed in the clamps of law seems the sphere of iron necessity; and such it is when taken simply by itself. But when the present stage of the Cosmos is regarded as a part of the greater totality of Nature, which in its turn is a stage of the All-Self, we begin to catch a gleam of the physical world in all its manifestations as part of the pro-

cess of the free Universe. For the Universe is the absolutely free entity, which can have nothing outside of itself to determine itself. Its free process is psychical, that of the Pampsychosis, as we have often called it, and is the inner process ordering all the parts of the Universe, since each part must have the process of the whole. So now in this particularized Cosmos we ask for the process which orders it inherently and at the same time integrates it harmoniously with the All.

We shall observe in this stage of the Cosmos many laws formulated and verified from the phenomena. There is the law of falling bodies, of the oscillating pendulum, and the so-called laws of Motion. All of these are to be taken into account, but the chief difficulty with them is that they, too, lie scattered over the field without any inner bond of union. They become almost as disconnected as the phenomena. So the multiplicity of laws is to be put into order along with the sensuous facts which they correlate. And we may repeat that this order must be psychical, suggesting its origin, and showing in its process the impress of the supernal source. Accordingly the Particularized Cosmos or Nature incorporate is to be seen fundamentally in a threefold process whose stages we may set down in advance as follows:

(I) The Moving Body—which suggests the immediate coalescence of Motion and Matter in one phenomenon. The primal stage.

(II) The Impinging Body—which shows the moving Body in conflict with its like. The stage of separation and strife.

(III) The Gravitating Body—which manifests the striving of the moving Body to return to unity with the earth and all Matter, the seeking to overcome the separation, without success, however. For the Gravitating Body, pushing for the terrestrial center, impinges on the earth's surface and so drops back into impact.

The Moving Body is, therefore, the starting-point of the present sphere; it is taken for granted, is something already created and is manifesting itself in the Particularized Cosmos, though its primal origin may be traced in the previous (elemental) Cosmos. But we shall now see it evolving until it gets to rotating and throwing off forms of itself, that is, new individualized bodies in Motion. Thus we may say that it comes back to its own beginning and starts to reproducing itself—which completes its cycle.

In the three foregoing stages the attentive reader will be able to trace what we call a psychosis—especially the psychosis of the Particularized Cosmos, which we are now to unfold more fully and to set forth in its concrete content. The theme of this Chapter might be called Matter moving, or Motion materialized; the two cosmical elements, Motion and Matter, are joined together in a kind of struggle for supremacy till Motion gets control

of Matter and whirls it in a circular orbit—wherewith the present stage passes over into the next.

I.

The Moving Body.

What is more common than to see a body in motion, and to feel it and also to hear it? A very trite phenomenon for our senses is such an object; still it is the combination and co-operation of the two primordial and elemental principles of Nature —Motion and Matter. These we have already seen as stages in the same cosmical process, and yet opposites also. Hitherto they have been held apart and looked at in themselves with their various characteristics. But now they are conjoined in one phenomenon, though still dual and even antagonistic. The moving Body is of course not pure Motion nor pure Matter; it is Motion limited and particularized in Matter, and Matter limited and particularized in Motion; each puts a bound upon the other and compels it to be real, finite, even sensuous. The Moving Body we call it, though we shall also take it at rest.

Now this Moving Body in its dual character exercised a wonderful fascination over Sir Isaac Newton, with whose soul it had some strange compelling affinity. His great work (the *Principia*) is properly a treatise on the Moving Body; or as he designates it, *On the Motion of Bodies*. His stress,

however, is directed to measurement, or to the mathematics of the moving Body. The Measure of the Motion of Matter is what evokes his genius. Let the reader note in this statement the three elemental principles of the Cosmos united.

Says Newton: "Geometry is founded in mechanical practice, and is nothing but that part of universal mechanics which accurately proposes and demonstrates the art of measuring" (*Pref. ad Prin.*). Geometry is, therefore, the first branch of Mathematics, or of Measure. Another passage runs: "All the difficulty of philosophy seems to consist in this—from the phenomena of Motions to investigate the forces of Nature, and then from these forces to demonstrate the other phenomena." Newton evidently means here by philosophy a science of Nature, which with him is almost wholly mechanical and cosmical. It is plain, too, that Motion, or rather the Motion of Matter, was the central phenomenon from which he was to extract his philosophy. This he did chiefly by means of geometric construction which is seen everywhere in the *Principia*.

On the subject of the Moving Body Newton starts out with three axioms, which he calls the laws of Motion. The first word (axiom) is the best for designating them, as they are immediate insights into the fundamental character of the thing, and not the result of proof. Moreover these "Laws of Motion" pertain to the Moving Body, as

is seen in the two words (*omne corpus*) which begin the first law. It may be said that these three laws of Motion have dominated the present field of physical science since their enunciation (in the *Principia*). They are very simple in form, quite self-evident, though they are subtle and pervasive, and seem to grow in significance as the physicist grows in knowledge.

The leading interest perhaps is to see the first phenomenon of Nature—the Moving Body, or the Motion of Matter—grappled with and reduced to order. Moreover the phenomena of Motion are very diverse; but here they are simplified and unified in what we see to be a single process, though this was a phase of the subject seemingly not recognized by Newton. For they are not merely three isolated truths or axioms about Motion, but they belong together and form one process, as we shall see.

It is well at this point to recall elemental Motion, the Separating of the Cosmos, which has now become embodied, and which in this stage is organized with all its outer diversity into inner law, or rather into the process of three laws. These are to be seen next in their application to concrete objects and to special cases. But they also reach backward to deeper-lying categories, and processes, such as Space, Time, Quantity. One may well ask of Newton, Whence comes that pivotal word of his (*corpus*) or its concept? He picks it up as

it were, and starts to find its law when moving, and also to measure this Motion of Matter. But the questions: What is this Motion and Whence—What is this Matter and Whence—What is this Measure and Whence—did not take hold of him strongly, though he glances at them now and then. Nor did it lie in the consciousness of his time to work back into such speculative or elemental presuppositions of Nature. Newton's century in science was essentially mechanical, not chemical, not biological. Of this scientific spirit he was doubtless the culmination, which is seen specially in his power over Measure, or in his genius for Mathematics, the mathematical being Nature's ideal machine, or the machine of all machines, which seems always to be running of itself in the Newtonian brain. The physical determinations of Nature were but a transparent shell through which he saw the universal mechanism working, and uttering itself to him in mathematical forms, especially geometric, for he was somewhat averse to the rising algebraic or analytic method introduced by Descartes.

We are, accordingly, to grapple with the three laws of Motion, or of the Moving Body, as the first stage of the Particularized Cosmos, or better, as the first process of it.

I. First Law of Motion. This is, in general, the law of the inert Body which is to become the moving Body:

"Every Body perseveres in its state of rest or of moving uniformly forward in a straight line (*in directum*), unless it is compelled by forces impressed upon it (*a viribus impressis*) to change its state."

Given the material Body at rest or in motion, what breaks into it and causes it to alter and diversify its condition? Some external force is the Newtonian conception. We may bring out the main points:

(1) The primal condition of Body is here given as rest, which implies its relation to the earth's center. For in the large outlook no Body is at rest in the universe; even the inert Body is always moving with the earth around the sun. So the scene is terrestrial, the Body is located on the surface of the planet. Such is the primordial rest with which the incorporate or particularized Cosmos starts. To be sure the starting-point is itself a result, indeed a result of Motion, as we shall see later.

(2) The second condition mentioned in the law is the motion of the Body in a right line when its rest may be supposed to be broken into. The earth's gravity is assailed, and the moving Body goes its own way, with its own center. We should note also the Body's rectilineal Motion, not circular, or self-returning. This second condition is a breaking away from the immediate influence of the earth, and a kind of self-assertion on the part of the Body, in which we may see an act of sepa-

ration from first unity between it and its terrestrial counterpart.

(3) Upon both these states of rest and motion, a new power may impinge and produce a change. This force (*vis impressa*) may bring the Body from rest to motion, or from motion to rest, or from one motion to another. There is a world of such forces outside of the Body at rest or in motion, which are always determining it anew and producing changes of state. Moreover, the moving Body is exposed to collision in an incessant whirl of other Bodies. The first law of Motion, accordingly, unfolds the conflict of the Particularized Cosmos sprung of its ever-colliding forces. The Body from its immediate condition is whelmed into a seething reservoir of conflict, at least as far as the earth is concerned.

The first law of Motion is often called the law of the inertia of the Body. This means its persistence in its given condition; if it be at rest it stays so, if it be in motion it continues to move. It has no inner power of determination; any change in its state must come from without. The corporeal world is a world externally determined; the first Body is devoid of self-movement. This is the opposite of the universal Self, which must be wholly moved from within, and has all difference inside itself. But the first Body possesses only stolid, persistent self-identity, all change in it must come from the outside.

II. SECOND LAW OF MOTION. We have reached an ever-changing world ot moving Bodies, or the first manifestation of the Particularized Cosmos. Next we are to see if this changeful appearance has not some principle which may flash a gleam of order through its seemingly chaotic diversity. Here is the second law in the present domain.

"Change of Motion is proportional to the motive force (*vi motrici*), and is produced along a right line on which that force is impressed."

Here Body is not directly mentioned, but Motion is the emphatic word. Still the Motion of Body it is which underlies the conception of the present law. The theme is corporeal Motion with the degree of the change and its kind, as well as its direction.

(1) The first concept here is that of the collision of Bodies, to which we are now specially introduced. A moving Body is impinged upon by another moving Body or motive force, and the result is a change of its motion.

(2) This change is proportional to the impinging power. Thus the world of conflicting Bodies has its proportion and is measurable. The greater the impact the greater the change; the one determines the other. We note here the division of the corporeal world into two parts: the moving and the moved. Yet each Body may be one or the other.

(3) The rectilinear direction of impact or of

these changes of Motion is specially emphasized. This right line is simply a continuation of the line of motive force, which thus determines the character, the direction and the quantity of the change of Motion. Matter as Body is now seen to be the transmitter of Motion as Force. The incorporate Cosmos before us is in a state of conveying increasingly Motion from particle to particle. And that Motion being limited has the tendency to be rectilineal.

The first law of Motion regarded the Body as such, in its immediate condition, whether at rest or in motion—in which condition it persisted unless compelled to change by an outside power. But the second law of Motion regards this outside power or colliding force, and makes it the measure of the change of Motion produced in the Body upon which it impinges. So we pass from one Body mainly to two Bodies with their conflict.

III. Third Law of Motion. The two impinging Bodies, one of which has just been shown determining the other, are now brought into a kind of mutuality of influence, in which they both are alike.

"To action reaction is always equal and opposite; or the actions of two Bodies toward each other mutually are always equal, and are directed against opposite parts."

The reciprocal relation of incorporate Motion is here formulated as action and reaction; it is well

to note the introduction of the two correlative words instead of force or motion. The two forces are opposite, yet equal, indeed alike in character; truly they are one in their very opposition, and form a process together. Upon this fact a few words may be added.

(1) The new point is that of counteractive Motion against the motive force which had the emphasis in the preceding law. The body assailed now seems to wake up and to respond by an equal assault, though it may be overwhelmed by a greater amount of force or motion.

(2) Two Bodies are now mentioned (*corporum duorum*), rather than implied, as they were not directly named in the preceding law. Moreover they are put on terms of equality and interrelation; there is still the collision, but it now is made mutual. The blow is given but each hits the part opposed to it—wherein again they are alike.

(3) Action and reaction in their very opposition are one in character and form together a round of Motions—action calling forth reaction, which is a return upon action with its own. The third law thus winds up not in circular Motion, but in a cycle of two Motions of two Bodies which make a totality of conception, and form a very suggestive conclusion of these three laws of Motion.

It may be further conceived that when the two colliding Bodies have spent their action and reac-

tion, they will return to their state of rest as inert Bodies; or to the state taken for granted by the first law. From such a point of view the third law has gone back to the beginning, and has rounded out the process of the moving Body in the present stage of the particularized Cosmos.

In other words, these three laws constitute a psychical process, that which we call psychosis. They are to be taken singly, but still more profoundly they are to be taken together. They formulate the elemental unity of all Moving Bodies, in fact of the whole Particularized Cosmos, of which they stand first as a kind of ideal prototype. It is this process which has given them their enduring place in the science. They deserve all the laudation of Professor Tait, but for a deeper reason than he presents. Singly they were known before Newton; the first must have long been the common property of every observer, the second had been employed by Galileo, the third is found in the works of Huygens and others. But it was Newton who put them together in their threefold succession and thus suggested their unity. Still he does not speak of their process or of their unitary character. That probably lay outside of his consciousness. At any rate he sets them down on the same page in the introduction to his *Principia*, to whose geometric demonstrations he evidently regards them as the axiomatic foundation which does not need proof.

These Newtonian Laws of Motion have not escaped criticism. Especially the first has been regarded as a special instance of the second and hence superfluous. But a little study ought to make plain that they are quite different, and that the only way to unify them is to see them as two separate stages of the one fundamental process of the Moving Body, to which process the third law also belongs.

Another distinction may be noted at this point: as we have had the elements of the total Cosmos (Motion, Matter, Measure) in our first chapter, so now we have the elements of the particular Cosmos in these three Laws of Motion. They may be deemed the general forms into which the real world of moving Bodies is to be cast. This real world is what comes next.

II.

The Impinging Body.

Conceive all finite Matter around us here on the terrestrial ball—what is its condition? It is pressing, pushing, colliding—in a word impinging. Even if we say it to be at rest, it is exerting a pressure, it shows impact. Already this idea came before us in the laws of Motion, all of which introduce a motive force which in one way or other assails and changes the state of the Body, moving or at rest.

As already indicated, the laws of Motion were vast generalizations, fundamental axioms laid down in advance of the manifold details of the real world of moving Bodies which now appears. The particularized Cosmos is here to be manifested in all its sensuous reality, which takes the form of impact in the present section.

It must again be observed that this world of moving Bodies, each asserting itself against the rest and yet each drawn earthward by gravity, means mutual collision, or a world of impinging Bodies. So we pass from a rather abstract or general sphere to a decidedly concrete one, which also has its place in the science of Nature.

What is to be done with this writhing, struggling multiplicity of impinging Bodies which everywhere meets our gaze over our terrestrial habitation? Certainly it is to be put into some kind of order which turns it from seeming chaos into cosmos, or into a phase thereof. And the law is again to be found, the law derived from its phenomena. But we are to observe that this second kind of laws are different from those of Motion already given, as they are not axiomatic in their character but are unfolded directly out of the sensuous facts, and usually express or imply some kind of measurement.

The question of impact has been a center of discussion in physical science ever since the so-called discovery of Gravitation, which controls all ma-

terial bodies through the most remote distances of the Cosmos. The sun attracts the earth. What reaches out from the former and pulls the latter? Is there a medium between the sun and earth which enables each to influence the other by direct impact? Or does one body move another at a distance without any intervening medium?

The problem, accordingly, turns on impact as the source of all motion of Bodies. This is what is familiar to us through our senses on the surface of the earth; but is this view, which holds here, to be made universal, to be applied throughout the entire physical universe? Mars is supposed to attract Sirius in accordance with the principle of universal Gravitation, which affirms that all bodies whatever attract one another with a force proportional directly to their masses and inversely to the squares of their distances. Now this action of Mars upon Sirius—is it immediate, the so-called *actio in distans*, or is it mediated through another body, perchance through the ether?

Newton, the formulator of the theory of Gravitation, kept aloof from any decisive answer either way, especially in his *Principia*, though he speaks more positively elsewhere. The question may be put in this form: Is Gravitation the result of impact, or an inherent property of Matter acting everywhere at a distance? The first alternative is unproved and the second is inconceivable, except as an occult cause. A universal mechanical view

of the world cries out for impact; and this seems to be the present trend of scientific opinion, which insists upon the aphorism: A thing cannot act where it is not. The wave-theory which has so successfully united Heat, Light, and Electricity has been invoked in the case of Gravitation also. The difficulty is that Gravitation seems instantaneous, and so is not measurable in time.

The problem, then, is still unsettled—the problem whether Gravitation is the result of impact, or is an innate, essential property of Matter. But whatever be our view on this speculative theme, we all have to say and think that Matter is heavy, and that weight is an immanent characteristic of it. Gravitation is measurable and is reduced to a quantitative law; nobody has been able to get behind it and to see what causes it, to find what other impinging body pushes or pulls two widely separated bodies. As far as experience goes, Gravitation is inherent in Matter, and works without direct impact, though such a view runs counter to making the Cosmos a universal machine.

And now it falls to our lot to attempt the organization of this vast realm of impinging Bodies, in the midst of which we live and act every moment. Our breath, our sight, all our senses strike against something, are in a state of perpetual impact. Each one of us, being embodied, is a center of infinite collisions with the world incorporate. And this world incorporate is in a continual fight with

itself; its Bodies are impinging or are ready to impinge upon one another. Nature is often said to be in an eternal condition of war; that is one statement of her inherent dualism. Yet in all this strife there is a striving for order and harmony. The domain of the impinging Body is making a tremendous effort to get out of itself; impact struggles to overcome impact; in other words it too is dialectical like total Nature, of which it is a part or stage.

So we shall attempt to run some lines of order through this realm of seeming disorder. In the first place there is the impact which is direct or immediate, as when bodies press one another simply through their own gravity—wherein is manifested the phenomenon of weight. In the second place, bodies impinge with added force or momentum, which is transferred from one body to the other—impact as translatory, which produces ever-flowing currents in the ocean of force. In the third place, an implement or machine is employed by man to seize upon and to direct these natural currents of force—impact as mechanical or mediated by a machine. These points will be considered in a little detail.

I. Impact as Immediate. Or we may call it impact by pressure, in which the impinging Body is inert, but is exerting the force of its inertia upon another Body, while this in turn gives back an equal counter-pressure. Both Bodies are striv-

ing to become one through mutual attraction, really they are striving to undo themselves as corporeal. And yet as Body each asserts itself against the other and maintains its separate existence by struggle, by what we may call resistance. Here we see the fierce dualism of the present domain, we may deem it the war always waged in the Particularized Cosmos. Each Body has its separate particular gift, which keeps it together, causing it to cohere as one against the others and even against the earth. This cohesive Body as a particularized piece of Matter will stay with us to the conclusion of Nature, being found still in the living organic world. But Cohesion specially will be attacked in the Diacosmos, and turned to the opposite of itself, as we shall see later.

At present, however, we are in the midst of the terrestrial conflict of the impinging Body as immediate, which also has its stages.

(1) The center of gravity is conceived as the point in the Body where the whole action of gravity is concentrated. It is a significant fact that every particle of matter, large or small, does not remain extended and scattered in its chief force, which is that of gravity, but shows a certain power of self-unification at a common inner point. Let the Body be broken to fragments, each fragment at once collects itself specially into a new unit of might and is ready for the struggle, having become an impinging Body in itself. The center of

gravity is accordingly a striking manifestation of the Cosmos particularizing itself into fresh forms ever prepared for impact.

(2) Two centers of gravity appear in this realm of impinging Body; the one is terrestrial, the other is found in every piece of incorporate Matter. The one is universal, or relatively so, that of the earth; the other is particular and is characteristic of the particularized Cosmos. Now these two centers of gravity belong together, and are always connected by an ideal line. When this line falls within the impinging Body, this is said to be in equilibrium, but when it falls outside the same—as we may see in the tipping of a chair—the Body loses its first equilibrium and seeks another, which will maintain the ideal line between its center and that of the earth. Thus every particular Body can be centered in itself only through the universal center; it cannot exist merely with its own center of gravity; if once decentered from the earth, it starts to restore the equilibrium, the line of connection. But the fact is that this connecting line between the general terrestrial center and the infinitely multitudinous special centers is always being severed and restored; bodies, impinging on one another, assail it and break it, producing the conflicts of the incorporate Cosmos.

The disturbance or loss of equilibrium is largely what produces Motion in Bodies inanimate. But living Bodies preserve their center of gravity while

moving. The four-footed animals have in this respect an easier task than man, who has gradually to learn to keep his equilibrium on two feet and to walk at the same time. In sleep, however, he returns to the position of the piece of inert Matter, yielding himself completely to Mother Earth, as one of her clods, and receiving in return her renewal and restoration.

(3) The relation between the two centers of gravity, the general and special, is measurable, and gives rise to what is known as the weight of bodies. To what extent will the earth's center pull toward itself the center of this given piece of Matter? A machine is constructed to tell the fact which is important to be known on many accounts. It is observed that bodies of the same bulk have very different weights; the matter in them is massed diversely, wherewith enters the conception of mass as a significant element of the particular body. Around their centers of gravity all bodies manifest different degrees of solidification through density and rarity. These various masses have the common characteristic of being weighable, and hence comparable with one another. A great orderer of the world of diversely impinging bodies is the spring balance and the pair of scales, since they reduce to one measure the vast variety of the incorporate Cosmos.

But before anytning can be rightly weighed,

there must be the third mediating body: the standard of weight, which is also impinging or has pressure. Find to what degree the center of this lump of coal is drawn to the center of the earth; next find to what degree the center of this stick of wood is drawn to the center of the earth; then we can compare the masses of two combustible materials. But we must have the third body (say the pound-weight) as the basis of comparing the gravities of the two impinging objects.

It belongs to the science of Metrology to ascertain the best standard of measurement. Each people persists in having its own; yet among scientific men of all nations the French standard has been adopted. But the interesting fact here is that amid the enormous diversity of impinging bodies, one is chosen as universal mediator. So we have in this field a mediation of multitudinous corporeal collisions; they are reduced to unity and order by the simple act of weighing.

We may now put together the process of the immediately impinging Body, which presses directly upon the earth. First is the one center of gravity; secondly we behold two centers of gravity, general and special; third is the mediating principle as above set forth.

II. Impact as Transferred. This implies double impact or the collision of at least two particular bodies, each having its own mass. In the previous stage of the impinging Body, impact as

mere pressure was the main consideration; strictly there was no collision, no impact of diversely moving bodies with their concentrated gravities smiting together. Impact here becomes explicit, active, an open war of the Particularized Cosmos —a war which was quiescent or merely potential where there was only pressure.

According to Newton's third law of Motion, action and reaction are always equal; the impinging Body gets back what it gives. That is, impact is imparted both ways; it is transferred from one to the other. The degree of impact is proportional to the velocity multiplied by the mass, and is called in physics the momentum of a body.

Mass has a somewhat different meaning from weight, which is rather the measure of mass. Some scientists, we note, trouble themselves a good deal about the exact significance of mass, but one can get along by considering it simply as the quantity of Matter in a body. In general, Matter may be conceived as differentiating itself into all the diverse masses of the Particularized Cosmos, each of which has its own separate massive character. Moreover the weight of the special mass is determined by the general center of gravity, and hence differs on the surface of every planet. It is estimated that a body weighing one pound on the earth would weigh two and a half pounds on the larger Jupiter, but only two ounces on the smaller Moon, while it would rise to more than twenty-

seven pounds on the Sun. Thus the weight of a body which is a chief element of its impinging power varies according to the planetary mass on whose surface it may be found.

The impinging Body with its concentrated might of terrestrial gravity, we are to see transferring its impact in various ways, of which we shall note the following:

(1) The well-known parallelogram of two forces with its diagonal gives a striking geometric image of the transference of impact from two bodies to a third. The diagonal is called the resultant, while the two adjacent sides representing the double impact are conceived as the components of the one resultant. That is, if two bodies moving from different directions impinge upon a common object equally movable with themselves, the result is a common motion compounded of the two impacts. On the other hand a single motion can be decomposed (or resolved) into two motions coming from a double impact. Thus the motion of a body is conceived as a compound capable of decomposition and recomposition similar to a chemical compound.

Again, the two impacts of two impinging bodies upon each other or upon a third may be mutually balanced or neutralized, so that the resultant is no motion, or is an equilibrium of impacts. A man cannot pull himself up-stairs by his boot-straps. A boy in his skiff finds that he cannot

push it with his oar against the stern. Arnott tells of a person who put a bellows into his boat and puffed a blast against the sail to impel his craft.

Thus impact in its transference may be united (compounded), may be divided (resolved), or may be equilibrated (neutralized). In these cases impact shows action on the one hand and reaction on the other, which are variously transferred. But now we are to see that impact both in its action and reaction can be imparted to and through other bodies.

(2) A row of billiard balls in contact may be taken for illustration. If a ball impinges on one end, the impact is communicated through the whole row to the last ball which flies off in response to the stroke, while the other balls remain as if at rest. Each ball transfers the original impact to its neighbor which does the same till the end ball is reached. Each ball reacts against the blow, and then converts this reaction to action against the contiguous ball. Thus in each of them action and reaction are equal, and the intermediate body, both impinging and impinged upon, stands still in an equilibrium of two opposite forces. The last ball receives the impact, but has no counter-impact from another ball, and so must yield. In the case of billiard balls, elasticity has a part in this play of action and reaction. But the main point is to see impact transferred

through a line of bodies, each of which mediates the two extremes. All the members of the series are equilibrated except the first and last which which are thus brought together, though at a considerable distance from each other.

This fact has a far-reaching significance. Impact, then, can be transmitted through Space by the mediation of intervening bodies. Not only solids, but liquids and gases will show the same property. Sound doubtless is propagated in a similar way through the air-waves. Heat, Light and Electricity stimulate a medium, which bears their impact far through space. The universally mediating ether, which is now getting so much attention, is supposed to have the power of an unlimited transference of the slightest impact throughout the physical universe.

(3) Impact as transferred can be measured and has its mathematical formula under the name of linear momentum. This is the force of the impinging Body, which is made up of two elements: the mass (quantity of Matter) and the rate of Motion, or velocity. The momentum of impact is found by multiplying together mass and velocity (expressed in the formula $m\ v$). Newton calls this momentum the quantity of Motion (Def. II. *Principia*), saying that "the quantity of Motion is the measure of the same, and arises from the velocity and quantity of Matter conjointly." The world of impact as translatory is thus quantified, reduced

to order through measure, and made tractable, yea useful. Mass is measured practically by weight, and velocity by motion in time; hence momentum is the union of two measures, which is preserved in the formula $m\ v$.

Impact as transferred or translatory we have seen in its three leading stages: first, as transferred immediately to the third body moving along the diagonal of a parallelogram; secondly, as transferred mediately through a number of intervening bodies; thirdly, as transferred universally according to a common measure or quantitative law, under which all the diverse impacts of the Cosmos are to be subsumed.

In this second stage of impact the translatory force was left to itself, the mediating body simply performed its natural function of translation. But now man will seize upon this mediating body with its translatory force, and transform its natural into an artificial function of translation. This new mediating body with its impact is called the Machine.

III. Impact as Mechanical. This still deals with impact as transferred, but this transference takes place in an entirely new way, namely by a mechanical contrivance. The mediating body still appears, but as transformed by man and filled with his purpose. The two extremes which the machine mediates are usually known as Power and Weight: the active Power is to be applied to

the Machine by impact of some kind, and the passive Weight is to be overcome in its resistance.

It is to be observed, first of all, that the Machine does not generate Power, but is to transfer it, distribute it, apply it. In fact the Machine always must cause some loss of the original Power applied to it, through friction and resistance of the air. Its peculiar character is directive, mediative, translatory; it is the great middle term between the world of impact with its working energy, and the inertia of Matter with its opposition to all change of state. The attempt has often been made to invent a machine which would generate its power inside itself, whereby there would be perpetual Motion. Of course such a conception contradicts the very nature of a machine, which is to receive its power from the outside and to distribute it in various ways. Such a self-moving machine could only be a living body. There is, however, a machine which in a sense may be called self-propelling—the locomotive which carries the generating force to drive the wheels from without. The machinery does not supply its own force but takes it along. Thus it is a synthesis of several co-operating machines which are ultimately driven by external impact. Still, the locomotive is the most impressive and significant copy of a living thing; we may indeed call it the free machine, which could only be invented and ap-

plied by a people animated with the conception of freedom.

The Machine has another trait of much significance: it can transform speed and distance into power. A man exerting a certain force in hoisting a weight of 100 pounds can with the same force hoist ten times as much by a system of pulleys, but it will take him ten times as long. Archimedes declared he could move the world by his machine, if he had a place to stand on. But his body would have to sweep through an enormous distance and at an enormous speed, in order to raise the earth a millionth of an inch in a million years. So it is often said that what a machine gains in power is lost in time, or it may be in distance. The impinging force can be increased a hundred fold by a mechanical contrivance, but it has to pay for it in Space or Time, or both. The machine is, therefore, a kind of controller of those two obstructive, though primordial elements of the Cosmos, Space and Time, exchanging them for increased power. In this respect a great destiny lies before machinery, as minimizing the hindrance or the separation caused by those two huge cosmical barriers, Space and Time, which have to be overcome by man in winning a higher freedom.

Herein the Machine puts its stamp upon an age or a civilization. The vast forces of Nature, running to waste, can be picked up and utilized by machinery which takes the place of the far weaker

muscular effort, and relieves the human being of a great part of his burden. In general the machine makes for freedom, though it may get to controlling the man instead of being controlled by him. So the machine can and does in individual cases produce servitude instead of enfranchisement. Ours is called a mechanical age, usually by way of disparagement. Its chief function is undoubtedly to harness the huge monstrous colliding powers of Nature to machinery and set them to work for ends useful to man, especially for his one ultimate end, freedom. It is noticeable that the freest peoples are the most mechanical, are the most successful and ingenious in the employment of the Machine.

The science of to-day has unquestionably a decided mechanical tendency; it grapples with and seeks to know the mighty impinging forces of the natural world and to fetter them in a mathematical formula, since mathematics may be deemed the universal or ideal machine controlling and mediating all Nature. Still further, the universe is often set forth as a kind of mechanism, and the world-view becomes mechanical, resting wholly upon external determination which is a denial of freedom. The All is declared unfree—which statement is a contradiction in terms, though many a philosophy is based upon it. The Machine, therefore, gets sometimes to be a spiritual mediator, which is not exactly its function.

We come back to the original purpose of machinery which is, in general, to mediate impact, or the force of an impinging body. It directs, distributes, and even concentrates external energy upon some resisting object; but it cannot increase the amount of such energy. Moreover the Machine as such, or the creative idea of it, splits up into a vast number of machines, or specialized applications of the one fundamental mechanism. But this prodigious mechanical multiplicity has been reduced to a few simple typical machines, well known as the mechanical Powers, which, however, can be brought into a single process. These points we may elaborate a little.

(1) We have first to grasp the Machine in itself, as it is in its universal genetic thought. This has been repeatedly stated: the Machine is the transferer of impact, or of energy, as this is often called at present; it is an intermediary between some impinging body and the body impinged upon. Moreover it is an artificial thing, usually man-made, and carries his purpose; through the Machine man deftly turns nature against nature. The kinds of bodies producing impact may be noticed. The primal machine-mover was the human organism which can generate motion. But the main development of machinery has been to relieve man more and more of his immediate burden. It is next put upon the stronger domesticated animals as the horse and ox. But the great present driver of

machinery is the forces of Nature, steam, heat, and especially electricity. The Cosmos is a huge reservoir of impinging power, which the Machine is invoked to seize and to utilize. The puny agent, man, has still to touch the button in order to set in motion the mechanism which is to perform for him gigantic feats of work.

(2) We may summon before us the one original primordial Machine and watch it differentiating and specializing itself in all the tools, weapons, implements and engines—in fine all the machines which man has made to hitch up the stray forces of Nature, setting them to do his work. Thus the conception of the Machine realizes itself and keeps realizing itself million fold down the ages in huger and huger shapes. New ones are always forthcoming in answer to the call of the time, which as before said, is mechanically minded, and old ones are thrown aside, being transcended. The evolution of the Machine in its agricultural, military, naval, and industrial forms would be a good mirror of man's social development.

(3) The indefinite and ever-increasing diversity of mechanical appliances must be somehow brought back to unity. Such is not only our psychical need, but also the inner movement of mechanism itself. Accordingly science has sought to reduce all mechanical multiplicity to six different machines, the supposed prototypes of all others, the so-called *Mechanical Powers*.

These six being accepted as fundamental, the question at once comes up in regard to their order, which has been variously given by different scientists. It has also been felt that these six are too many and need a further unification. The Lever and the Inclined Plane have been sometimes regarded as the principal Powers of the six. This view would seem to underestimate the Wheel and Axle as the circular Machine. But without discussing further these divergences of opinion, we shall put the entire six into what we deem their true process, which is of three main forms, or stages.

(*a*) The *Lever* is rightly placed first, as the simplest in form, the most primitive, and indeed the potential one of the Mechanical Powers; implicitly it has within itself all the rest, and may be said to contain the germ of total machinery. It is a bar or rod quite inflexible in which three points are specially to be taken into account: the end where the impinging force is applied, usually called the Power (P), the intermediate point at which the transference of this Power takes place, the Fulcrum (F), and the object which receives the transferred Power known familiarly as the Weight (W). The elements of the Lever (P F W) are, therefore, three—the active impact in one direction (say downward), the changed impact (say upward), the received impact on the resisting body—which last impact is a return to the first, though changed in direction through the media-

tion of the second. In all this we see that the Lever is the simplest sort of a contrivance to direct the force of an impinging body from one line of movement to another. We may also see that it performs by its action a process: the given force from the outside, the change of that force from its path, the return and re-assertion of the same force as changed.

But there is not alone a transfer of force through the Lever, there can be also an increase of it. The Power, for instance, is doubled in effect, if it be twice as far from the Fulcrum as is the Weight. Still it has to pay for such increase by moving through a proportionately greater distance, as already noted of the Machine generally. Or we may say that Space (or Time) is exchanged for Power—which is the peculiar characteristic of all mechanism.

In the ever the Fulcrum, the pivot of change, is fixed, and in one way or other rests on the earth whose inertia or resistance it utilizes for deflecting the original Power (say from downward to upward). The earth, then, is the ultimate mediator. Yet in this act the earth is turned against itself, against its own gravity represented by the Weight. So in the final thought the Lever turns one terrestrial property or force against another. We may also regard this as the germinal function of the Machine.

There are, of course, many kinds of Levers;

one division of them comes from the different positions of its three elements (P F W). Then there is the combined or compound Lever. But these various forms we shall pass over.

(*b*) What comes next in the order or process? The second Mechanical Power is, as we arrange this subject, the *Inclined Plane*, in which the Fulcrum is movable as the Weight is rolled up the incline. The simplest form of this mechanical contrivance is seen in a plank slanting from the end of a wagon, up which plank a barrel is rolled into the vehicle. The Power which moves the Weight is twofold: that of impact and that of the Inclined Plane, which partly supports the Weight, but whose upbearing force is ultimately that of the earth. It is to be noted then, in the present case, that the Power is divided and that the Fulcrum is continually separated from its place in its movement up the incline. For the Fulcrum, we must recollect, is the point at which the Power has its thrust changed and is directed upon the Weight. In the *Wedge* the whole Inclined Plane moves against the resisting body which it may raise in opposition to gravity and split open against cohesion. The impact may be a blow or a steady push, whose force is changed in direction at the point where the impinging Wedge meets the obstruction. Thus the Fulcrum here too is movable. The Wedge is often a double Inclined Plane for increased effect. The Wedge has a wide applica-

tion and is of many sorts. Knives, pins, needles, nails, scissors, all cutting and pointed implements are wedges. The Wedge is a movable Inclined Plane but in a right line on the whole; but now we come to an Inclined Plane which is curvilineal and moves in a continuous spiral, *the Screw*. The Fulcrum is not only movable from point to point but is at every point in the thread of the Screw, it works along the entire spiral, thus it has become general in this sphere of the Inclined Plane, occupying it everywhere. Moreover the Screw is really a double Inclined Plane with thread and groove.

Thus we observe that among the Mechanical Powers the Inclined Plane takes three forms which have the incline in common, but which are distinguished by the Fulcrum moving on the incline from point to point in succession, and then being moved by the incline from point to point in succession, and finally moving on the incline at every point and at the same time. Thus the Inclined Plane passes from the rectilinear to the curvilinear form, and with its spiral is evidently seeking the circle, which now appears in a new Mechanical Power.

(*c*) In what we call the process of the Mechanical Powers we have come to the third main stage or form, that of the Wheel with its rotatory or completely circular movement. The *Pulley* is simply a Wheel turning on a pivot (or Fulcrum) which changes the direction of the Power exerted

usually in hoisting the Weight. The Pulley is combined diversely into a system of Pulleys.

The *Wheel and Axle* is properly two wheels of different diameters. The large one receives the Power and may be regarded as a kind of circular or universal Lever whose impact is continuous. The small wheel or the axle is the circular Fulcrum moving with the large wheel, but reversing the direction by means of the reversed rope, which usually lifts the Weight from below. The greater the difference between the diameters of the two wheels, the greater the Power but the slower its movement. The considerable diversity of forms of the Wheel and Axle is seen in the windlass, the capstan, the hundreds of hoisting machines with complicated wheel-work. The wheeled vehicle with its two or four wheels turning on fixed axes by means of the applied Power, but changed in direction by the resistance of the earth might be called a third form of these circular Mechanical Powers.

It should be noted that the Wheel and Axle is the Lever made complete or universal, the latter's partial movement through an arc becomes a full circle and continuous; moreover the force can be drawn off in any direction by a system of wheels large and small. Also the radius of the Wheel and the radius of the Axle are comparable to the long and short arms of the Lever both in character and efficiency. But the one is a particular and the other is a universal Lever, which thus has run its

course, and therewith has brought to a conclusion the process of the Mechanical Powers.

In this process we should emphasize that the pivotal point is the Fulcrum, truly the pivot of the mechanical system. The chief object of the Machine is to change the direction of Power or of the force of impact. This change takes place at and through the Fulcrum, whose ultimate mission is to direct one terrestrial energy against another, to turn Nature against Nature. Now in the Lever this Fulcrum is in one position, essentially fixed; but in the Inclined Plane it becomes movable though variously movable throughout the three different Inclined Planes; finally in the Wheel and Axle it is fixed in its movable round or circle (different from the spiral of the Screw). Thus the Fulcrum passes from its simple fixity to one point in the Lever, through its movability on a continuous line in the Inclined Plane, to its final fixity in one self-returning circular movement in the Wheel and Axle, which movement is now not merely continuous for a given distance, as in the spiral, but perpetual as far as the Machine is concerned, which has no end in itself (though it is limited externally by the work to be done), while the rounded Screw with its spiral comes to an end in itself. Thus the ideal circle of the Mechanical Powers has completed itself in the real circle and has manifested itself to the senses—which is the way of Nature.

The movement of the Mechanical Powers is the movement of the Lever from its first limited particular stage to its universal form in its circularity. The name of the old Greek, Archimedes, is peculiarly connected with the Lever, which may be deemed the germ or cell of the Mechanical Powers. As the first and simplest machine, it can be taken as man's starting-point in the conquest of Nature. Man, too, has a body impinging and impinged upon, so he is involved in the great battle of Impact, in which he has not only to defend himself but to conquer. The impinging Body thus plays a great part in human life. It is indeed dialectical or self-undoing, for, universally considered, it is in a perpetual assault upon itself, seeking really to overcome itself. Now it is this property of body's self-undoing that man takes advantage of through a cunning contrivance called a machine, which seizes upon and controls impact, that is controls body destroying or transforming body. All agriculture, all manufacturing, all engineering, primarily set one body to impinging upon others, make them fight as it were. Herein we may also glimpse the fact that the function of man in the present sphere is to get control of this dialectic of Nature, and to direct it toward fulfilling his ends. He did not originally beget her dualism, from which springs all her energy—that came, according to our view, from the Pampsy-

chosis—but he must master it or be pushed by it to the wall.

The final act of the impinging body as machine was to go back to the body pressing immediately upon the earth and to hoist it, or to separate it from its unity with the earth. But the machine as well as the pressing body rests upon the earth; thus it has to undo in another what it itself is doing. The machine counteracts gravity in the body while obeying gravity in its own case. Such is the inner contradiction in all machinery, which is next to be solved; both the machine and its burden have a common principle in terrestrial gravity. Truly the whole realm of impinging Bodies, which we have just passed through, has in all its opposition an underlying obedience to the earth's attraction. In fact we shall find that just through this common attraction shown in their weight, do bodies get their force of impact, or their power of collision. Thus the separation of this second stage of the Particularized Cosmos—that of the Impinging Body—is overcome, and moves of itself into a new unitary stage, that of the Gravitating Body. For all colliding terrestrial Bodies gravitate in common, even while colliding, toward the center of the Earth, and thus show their one basic principle, to which they will return.

III.

The Gravitating Body.

It is in order now to go back to the Moving Body (which was considered in the first section of the Particularized Cosmos), and to note that it is a Gravitating Body. That is, the motion of Body has its ground in Gravitation, that force or power by which every material particle in the physical universe is drawn toward every other particle, according to the well-known law of Newton. Whatever original or elemental Motion may be regarded, a Body moves through the attraction of some other Body or Bodies. To be sure, it can be relatively brought to rest by the same force. But that which we have called the Particularized Cosmos is a vast complex of intergravitating Bodies, great and small, of which the earth, with its environing field of attraction, is but a minute speck. Still it is that which we are now mainly to consider. So we return, as it were, to the Moving Body and seek to find the ground of movement in this mutual Gravitation of the incorporate universe. We may here add that even this ground is not ultimate, for in Gravitation we pre-suppose both Motion and Matter to be primordial and elemental, as already set forth; still, these original twins of Nature must likewise be derived, must be shown in their parentage.

At present, however, we are to consider Gravitation as the universal interconnecting power of the Cosmos particularized in an endless diversity of Bodies. It is universal; it cannot be deflected or influenced from without, like Heat, Light and Electricity, for instance. It is eternal, it cannot be generated or destroyed, does not arise or decline anywhere in the Pancosmos, except according to its law. It goes through all Bodies in its path, without increase or diminution, quite as if nothing were there. It is instantaneous, defying attempts to measure it hitherto; Laplace has a calculation that it must move at least 50 millions times faster than light. It is not reflected, refracted, or diffracted; as universal it is inexhaustible and never fails to act and to act completely. Its action is, therefore, not intermittent or capricious, but is subject to unvarying Law—it works upon all Bodies directly as their masses and inversely as the squares of their distances. Space interjected between material objects has thus a power of lessening their Gravitation; it separates and clogs the great uniter of the physical universe. Space is, accordingly, more elemental than Gravitation, which is really the struggle to overcome the spatial separation of the Cosmos.

This thought brings us to consider that the Gravitating Body, which is now our special topic, is a return out of separation, particularly separation from the earth. Moreover, such a return is rela-

tively free, that is, the Body goes of itself toward the center of the earth, the obstacle being removed. On the other hand, to separate it from the earth requires the special exertion of a separative force, such as a machine can produce, for instance. Impact we have seen to be the world of colliding Bodies whose forces are directed one against the other. The Impinging Body is in conflict, ultimately in conflict with the unity of Gravitation. The Gravitating Body, accordingly, is the overcoming of the conflicts of the Impinging Body. Underneath all pressures, collisions, impacts, we have always Gravitation lurking, as it were, and secretly active. But now it is to become explicit and to show itself controlling Bodies in their own right.

The Gravitating Body will, therefore, return to its source, to mother Earth, whence it originally came. To be sure it will be stopped before it reaches the terrestrial center, which, if it once could attain, it would cease to be corporeal. The Earth, too, is a Body and asserts itself as such. Hence the attempt of the Gravitating Body to drop down to its source does not succeed fully; the separation of the two still remains, even if quiescent and potential. But it shows the striving, the mighty striving of the universe to become one, even through separation. It is, therefore, remanded to its place in Nature, which is the second, or separative stage of the All-Self, as has been frequently stated before.

Gravitation, accordingly, presupposes the universal separation into the Particularized Cosmos, which it aspires somehow to re-unite. We shall hence esteem it supremely the cosmical force directed against the world's original diremption, manifesting Nature's negation of her own negative. On the other hand, we shall meet later with many a protest against the unity of Gravitation. What else is light raying out in opposition to attraction? For this reason, among others, there will arise in opposition to the Cosmos with its Gravitation the Diacosmos, which, however, lies quite a distance ahead of us.

At present, then, we shall confine our look to the Gravitating Body, which will bring to the surface a succession of movements which, closely scanned, will be seen to form a process in itself with three stages. The Body under the influence of Gravitation will first fall simply toward the center, of course without getting there; next we shall see it under given conditions falling and then partially rising in an arc (the pendulum); finally this arc will be extended by returning into itself and thus becoming circular—wherein the fall of the Body may be seen to have rounded itself out into its completeness. From this point of view the Body no longer falls into collision, but rather out of it, and the Particularized Cosmos, the realm of conflict incorporate, is brought to a close.

More briefly we may designate these divisions of

the Gravitating Body as follows: (I) the Falling Body, (II) the Oscillating Body, (III) the Rotating Body. These heads we shall expand in a little detail, trying to see them not merely as separate but as inter-related in a process.

We may again emphasize that this whole sphere of the Particularized Cosmos is brought to rest or to harmony in the Gravitating Cosmos after the many collisions of the Impinging Cosmos, which has just been set forth. So we behold here a movement from the primal identity of Body through its separation and struggle to its final unity through Gravitation. Such is the process, and we shall see it repeating itself in the various stages of the Gravitating Body, which are now to be given.

I. The Falling Body. We conceive the Earth with its controlling sphere of influence to have the power of drawing toward its center all smaller bodies. They fall to the terrestrial surface from a given point at which they may be regarded as in a state of rest. The fall of the Body is looked at from one side, which, however, calls for its counterpart, its rise—the latter being against Gravitation. The bullet of a gun shot directly upward stops and descends, manifesting in its free movement the law of the Falling Body. Strong force had to be used to send the bullet up, that is, to produce the separation from the Earth. But this force is overcome gradually, and the same force in the same gradation is given to the bullet in its descent by

Gravitation, which thus offers a line on which it can be measured.

And now we are to see this simple fall of a Body passing through three essential stages which form a process, or a psychosis.

1. *Identity of Fall.* The first fact of Falling Bodies is that each and all descend equally to the earth. That is, all Bodies gravitate identically with the same power of attraction; whatever be their size, shape, composition, they fall through equal spaces in equal times, if left purely to themselves, and unhampered by no outside opposition—which is experimentally shown in the vacuum. Thus every separate Body is the same in its separation, and manifests this sameness. Such we may deem the primal identity of the corporeal Fall throughout the physical universe. Yet this Fall has its expression in law.

The velocity of a Body falling to the earth is identical whatever its mass. If one Body is of a certain mass, and another Body is of one-fourth of the same mass, both will have the same velocity of descent. This was shown by Galileo in his famous experiment of dropping two balls of unequal masses from the top of the tower of Pisa. The so-called light bodies are obstructed in their fall by the resistance of the air; but in a vacuum the feather and a nickel will descend in the same time. So we come to the conclusion that neither weight nor density can make any real difference

in the velocity of Falling Bodies. The greater the mass of the Body, the greater is the Earth's pull on it; gravitation appears to adjust itself to what is required of it, exerting itself more or less according to the quantity of Matter. On the other hand all Bodies make a push equally for the earth irrespective of their properties—be they dense or rare, heavy or light. In this regard they are all alike, being ultimately of the one common Matter, which strives to overcome its separation. In this striving the largest and the least, the thinnest and the thickest, are one, and show such oneness in their common and indeed equal rush for home. Accordingly every Falling Body has one and the same speed earthward. Such is the universal character manifesting itself amid all their other diversities. The quantity or quality of their Matter makes no difference in their Gravitation. And yet there is a difference in their sphere, which is now to appear.

2. *Difference of Fall.* When Time enters, especially when it enters Space, division and difference go along with it (as we have already seen in discussing Space and Time, see preceding p. 59, etc). The fall of Body is spatially the same, but gets different with each successive moment, becoming more rapid. Thus into the identity of the fall difference is introduced, which, however, does not thereby escape law. All corporeal falls are alike, but each fall is different within itself. Still this difference has its own norm of being.

As the velocity of Falling Bodies is universal, the mind seeks an expression of that universality in a law. As they all fly to the earth at the same rate, what is this rate? Or what is the Space fallen through measured in units of Time? For these two cosmical elements (Space and Time) are now to obtain measurement, that is, they are to receive the third element of Motion, Quantity (see p. 70, etc.), thus becoming definite and capable of being handled. Over How-much of Space in How-much of Time is the demand which brings Quantity (How-muchness) into the fall of the Body, or into its special Motion.

This law may be stated thus: "The Space passed through by a Falling Body in a given unit of Time (say a second) is proportional to the square of that Time."

Our first reflection upon this law is that in it we find the three primordial cosmical elements: Motion (the fall), Matter (the body), and Measure. Still further, as it is Motion specially which is measured in the fall of the Body, we observe in the formulation of the law the process of the three original stages of Motion—Space (the quantifiable) Time (the quantifying) and Quantity (the quantified). We see that the Space and Time of Motion are incomplete and indeed chaotic till reduced to the order of Quantity.

The Space traversed by a Falling Body in a second of Time is a little more than 16 feet, (stated

exactly 16.09); in two seconds it will be four times as much, and in three seconds nine times as much. Let 1, 2, 3, 4 represent the times, then 1, 4, 9, 16 will represent the spaces. It is to be noted that both Space and Time have already their own special measurements in feet and minutes, which are presupposed in the Measure of the Motion of Matter, here the velocity of a Falling Body. Also to be noted is the fact that the point or unit of Time (succession) is correlated or proportioned in the squared Space (extension).

3. *Unity of Fall.* The preceding variations or differences in the one fall will be found to have their common principle or their unity, which is also expressed by a law. This is seen in the fact that the fall of the Body, while always accelerating and thus varying, shows the same amount of acceleration at the end of every second of the fall. Thus under all the changes of the falling Body runs a unity; we may say that through its difference and separation moves a return to identity, which, however, is not the first immediate identity (the simple sameness of the fall of all Bodies), but a new identity mediated through their difference. This we may illustrate by some details.

In the regular treatises we find the law of the increase of velocity of a Falling Body. This may be stated as follows: "The velocity gained by a Falling Body is proportional to the duration of its fall." Now the velocity gained at the end of

one second is 32 feet, at the end of two seconds is 64 feet, at the end of three seconds is 96 feet, at the end of four seconds is 128 feet. In these cases we observe that the duration of the fall in seconds is multiplied by 32 feet, which amount gives the velocity gained.

Thus the acceleration by gravity produced upon a Body freely falling to the earth is a constant quantity (32 feet) during any number of seconds, but the velocity itself varies with that number. The Body gravitates toward the earth with the increment of Motion every moment, never losing what speed it has before gained. Thus the velocity increases regularly through all the differences of time.

If we put together the foregoing three statements about Falling Bodies, we observe in the first case the identity of Gravitation—all Bodies fall equally, moving through equal spaces in equal times; in the second case they fall through unequal successive spaces in equal successive times (wherein Space and Time are both divided); in the third case the identity of Gravitation is again asserted, but in regard to its increment of velocity—its acceleration is the same, though successive velocities increase in successive times. Or more briefly: (1) all Bodies gravitate alike; (2) each Body gravitates differently at each different moment; (3) each Body gravitates with the same increment of velocity earthward. All Gravitating Bodies are,

therefore, one in their gravitation, separative in velocities, but one again in their acceleration or increment of speed.

It is evident that the laws of the Falling Body imply, though they do not explicitly formulate, universal Gravitation. Galileo (1564-1643) was the first man to prove experimentally the laws of the Falling Body. He very dexterously employed an inclined plane in making his discoveries. All three of the foregoing propositions belong to him, but he confined the Falling Body to the earth. It was left to Newton to prove that the fall of the Body was universal, that it was true of moon, sun, and planets. Thus he rose from gravity to gravitation, from the Earth to the Cosmos.

What next? The fall is evidently the first and simplest action of the Gravitating Body, which therein moves directly toward the one center, the terrestrial. But now a new center is brought to light, the so-called center of suspension, which also determines the fall of the Body, though in an opposite way. Thus the Gravitating Body is no longer single-centered and simple in its fall, but double-centered and dual; it moves down and up, to and from each center in succession. In other words it oscillates, manifesting in reality what we have already seen ideally in the movement of elemental Time (see p. 64). The primordial oscillation of Nature is just now, in fact is just the Now, which is always going on and coming back to

itself. This is what we are next to see embodied in our Particularized Cosmos.

II. THE OSCILLATING BODY. This is, in general, the pendulum, which takes a great many forms. But the typical form of it has three elements: the center of suspension, the separating line of suspension (thread, wire, etc.), the object suspended (the bob of the pendulum) which moves freely about the center of suspension. The pendulum may be said, therefore, in its motion to describe the arc of a circle with a given radius from a central point. When it is at rest the three centers are in line—the center of gravity of the earth and that of the bob with the center of suspension.

This line of gravitation, or of equilibrium, is broken when the bob is lifted up and allowed to drop of itself toward the earth. But the result will be the curvilinear oscillation, not the rectilinear fall. Terrestrial gravity will pull the bob down to the line of equilibrium, then its own inertia will carry it upward against gravity till the latter overcomes it when it descends on the same path but in an opposite direction. Again it will sweep upward beyond the vertical line of the three determining centers and then return, but always with diminished energy, till gravity at last overcomes it and settles it in the line of equilibrium. These arcuate motions of the pendulum are called its oscillations (generally the word oscillation means the complete sweep going and return-

ing, but in French writers it means the movement in one direction only, and the total is called a double oscillation).

Thus the Falling Body becomes the Oscillating Body when it is determined from two opposing centers, that of suspension and that of the earth; the one keeps pulling it down and the other keeps pulling it back. Such is the primal dualism of oscillation, which is a kind of compromise between the antagonistic forces. Then the third force plays into the motion: the inertia of the bob which at first unites with gravity and then turns against it toward the center of suspension. The oscillation is the very sign of doubt, of fluctuating from side to side between two motive energies. The Falling Body shows no such dubitation, no such twofoldness in its action; it goes straight for the terrestrial center without turning back upon itself.

At this point another variation shows itself. On the equator, which is bulged, a pendulum is farther from the earth's center than at the poles, which are flattened; the result is that it beats more rapidly in the latter case. It was Richer, a French astronomer, who first made this important observation in 1671, when he journeyed from Paris to Cayenne; in the latter place, which is near the equator, he found that his accurate Parisian clock was losing two minutes and a half daily. Huygens, and after him more fully, Newton, showed the right cause of this phenomenon. Thus the

pendulum can be used to determine the form of the earth. A good clock carried from the equator to the poles will indicate by the increased rapidity of its oscillations a continual alteration of the sphericity of the globe.

Now, this oscillation of Body will likewise have its process quite similar to the fall of Body, and will be expressed in the same general categories—simple identity, difference, concrete unity By the older physicists the pendulum is called the funipendulous Body, as if it were suspended by a rope and swinging. Its three main phases we shall briefly note.

1. *Identity of Oscillation.* Every material Body is oscillatory; it is not only in Time but is Time—Time incorporate and phenomenal. Herein all Bodies are identical, different as they may otherwise be in substance, form, mass.

The time of the oscillation does not depend on the substance of which the pendulum is made. Lighter wood or heavier metal will produce equal beats. In a vacuum all matter will oscillate alike. This is similar to the first proposition concerning a Falling Body; neither weight nor density can make any difference in the time of the fall. Both facts are results of the same principle of Gravitation: its action is the same upon every particle of Matter in the universe.

And yet difference will enter into the oscillatory movement of each and every pendulum, though all are alike in being oscillatory.

2. *Difference of Oscillation.* At what point does this separation come in? Each individual pendulum changes within itself, according as it is made longer or shorter. Its beat, we say, is faster or slower; the difference again lies in Time ever dividing into moments, to which the pendulum shows a peculiar adjustment, and of which indeed it is a unique, visible manifestation. Here, too, there is the law expressed in Measure or mathematically.

When pendulums are of different lengths, their times of oscillation are proportional to the square-roots of their lengths. For instance, a pendulum beating seconds is about 39 inches long; in order to beat half seconds it would be one-fourth as long; in order to beat quarter seconds it would have to be one-sixteenth as long (about 2.44 inches).

Thus the units of increase in the oscillation require the corresponding units of increase in the lengths of the pendulum to be squared. It has been estimated that a pendulum of an hour's oscillation would have to be some 8,000 miles long, equal to the earth's diameter about. If we compare this law with the second law of Falling Bodies, we find again that the increment of Time demands the square of corresponding increment of Space; the times of the oscillation being 1, 2, 3, 4, the lengths of the pendulum will be 1, 4, 9, 16.

But with all this variation and difference in the

oscillations of the one pendulum, they have their underlying common principle, they show a unity which is best conceived as a return out of the foregoing stage of separation into a new identity, or a concrete unity which contains difference.

3. *Unity of Oscillation.* Every oscillation of the same pendulum is made in the same time; if it beats seconds, every beat is a second. Thus a uniformity penetrates and orders all the diversity of oscillation, which may diminish in amplitude but keeps up the same duration. This is known in Physics as the principle of isochronism, which is usually put first without regard to its stage in the process of the oscillatory Body.

The above Unity of Oscillation finds expression in a law which may be stated: The times of oscillation are equal in the same pendulum; that is, its oscillations are isochronous. These may diminish in amplitude, say from four degrees to a fraction of a degree before equilibrium; but their times will remain constant. In other words, the period of a pendulum does not depend upon its amplitude. In this quality the value of the pendulum as a time-keeper consists: it is the essence of a clock, whose other machinery is to keep it going, and to mark its oscillations upon the dial. These are on the whole very uniform in the same place, though a change of terrestrial gravity in passing from equator to poles we have seen causing a change in their times. That is, the periods which on the

spot do not grow less with the loss of amplitude, do grow less (the time-piece gets slower) in passing southward to the equator.

Galileo was the discoverer of isochronism, which, according to the story, he observed by watching the swing of a lamp in the cathedral of Pisa (seemingly his mind was not upon his prayers). Huygens first gave a true insight into the theory of the pendulum in a famous book, (*De Horologio Oscillatorio*, Paris, 1673). Newton continued the work in his *Principia* (see Section 6th, Book II, where he treats of "funipendulous bodies"). Here occurs his important distinction between quantity of Matter (or mass) and weight. Says he: "the weights of the same body in different places" on the surface of the earth are variable, in accord with "the variation of its gravity." But he always found "the quantity of Matter in bodies to be proportional to their weight"—a fact which he tested "by experiments made with the greatest accuracy," doubtless at different points. This gives a little glimpse of Newton, the careful experimenter.

The dominating fact of the pendulum in our modern world is the application of it as a time-measurer. The idea of such a mechanical contrivance is said to go back to Galileo, but the invention of the first pendulum clock is usually ascribed to Huygens. Besides these famous physicists, other less known claimants have had their advo-

cates. This was probably like so many other inventions: several people came upon it independently about the same time. (A strong claim has been made for Joost Bürgi, of Switzerland, the natural home of clocks and watches. Other nations have contestants. See Cajori, *Hist Phys.*, p. 36).

With isochronism the oscillating Body has run its course, having unified within itself and reduced to law all its variations, we may say all its struggles. In a sense it has rounded itself out as a process, but it has not yet advanced into its own full circle, from which it always drops back ere attaining. Such is its visible manifestation of its weakness, its insufficiency, its finitude. We can behold its inherent dialectic (so we name this act of Nature generally) in its very motion, which keeps forever undoing what it has done, progressing then taking the back track, trying boldly and then giving up. Really it cannot overcome its own inner separation, its innate dualism, against which it is always reacting, yet to which it is always yielding. It remains a part though under perpetual protest; yea it remains two parts, but it cannot reach and be its own whole and thereby complete itself. Yet this whole is just what actually is in the universe, and the oscillation must universalize itself and pass over into the following stage. Or let the bob of the pendulum whirl through its total arc; then this vanishes into the next.

III. The Rotating Body. The circular movement of a Body naturally succeeds the oscillatory; the segment of the circle may be conceived as calling for completion. The part strives to be the whole of which it is part. The pendulum furnishes the center, the radius, and the suggested circumference of a circle in which a Body is to move. In the oscillation we notice the twofoldness, the arc forward and then backward; then each arc is divided into a fall and a rise, from and toward the center of suspension; gravity also is separated, being at first followed and then opposed by the movement of pendulum. Oscillation strives but cannot reach: it drops back and retreats on its own path. The two centers, that of suspension and that of gravity, show their struggle in the oscillatory movement of the intermediate bob, alternately winning and losing, till the two contesting forces bring the pendulum to a rest between them in the line of equilibrium.

The completion and fulfilment of the oscillation is the rotation of the Body, which does not now retreat to its starting-point but advances to the same. The partial motion rounds itself out, returning into itself through its totality and forming the circle, which has its own center as well as the earth. Gravity is overcome being unable to break up the circumference into segments. The motion of the Body is no longer divided into two opposite oscillations and then into two opposite semi-oscilla-

tions. This inner separation and dualism is harmonized and unified in the one circular movement. The Body, first gravitating toward the earth's center in a straight line, then oscillating between the two centers in a curved line, has now gotten its own center of movement.

In the Rotating Body we can find the same general process that was observed in the fall and in the oscillation of the bodies. The same terms may be employed in designating its stages; thus the common movement which pervades this entire field of the Gravitating Body will be brought out more plainly.

1. *Identity of Rotation.* It seems trite to say that all bodies are capable of being rotated; but not so familiar is the conception that the first motion of the universe, the primordial act of matter, was doubtless rotary. From this original creative Rotation all other forms of motion may be conceived to be derived.

The most common kind of the Rotating Body is the Wheel which we have already considered in treating of the Mechanical Powers. In general the simplest form of rotation is the rigid Body moving around a fixed axis. Such a Body shows a certain independence, having its own center and its own motion about its center. To a degree it has become self-centered, actively so through its rotation. From this point of view we may deem it a little image of the earth. Rotating, it is de-

termined from within, partially at least. A higher individuality and self-assertion it manifests through its rotation than through it fall or its oscillation. Indeed it defies and transcends both after its manner. Still the rotation of a Body has its limits; urged beyond a certain speed it undoes itself—the wheel flies to pieces, and the round darts into the rectilineal.

2. *Difference of Rotation.* That is, the Rotating Body differentiates itself through its own act of Rotation. At a certain point of velocity its cohesion is overcome, it flies into multiplicity, it became reproductive, or using a biological analogy, it shows itself fissiparous. Thus the Rotating Body reveals the tendency to divide within itself, to rush from the one center into many centers, to incorporate itself anew in separate forms of matter.

The tendency of the particle of a Rotating Body to rush from the center may be seen in the mud flying from the rapid wheels of a carriage, or in the bucket of water whirled overhead by the hand. It is to be noted that these separated particles fly off at a tangent to the circular path of the body, which thus projects its pieces in a right line. This is often called the centrifugal force produced by Rotation. The stone of a sling when the string is loosed, is an example. The strong fly-wheel if rotated too rapidly will break to fragments, which may be hurled in all directions on tangential lines. But the most interesting example is the rotatory

motion of the earth, which probably produced the moon, and was itself produced originally by the rotating sun of which it was a part. So it is conceived that the whole planetary system was generated by Rotation, which thus manifests itself as the creative principle of the separate cosmical bodies. In fact each piece of matter can be made to yield up its cohesive individuality, to surrender its own self as it were, and to beget others like unto itself, through the rotary act.

But now follows a fact of deepest significance: the separated or generated body is also a Rotary Body like its source. Thus all these different corporeal forms become one in a common principle.

3. *Unity of Rotation.* We may repeat that this unity is not that simple identity with which the present sphere started, but the concrete unity which springs from, embraces and unifies the foregoing difference.

The fragments separated and flung off by the Rotating Body themselves rotate; thus the rotation in a manner reproduces itself. The stone speeding on its tangential path from a sling will spin; its outer particles have been moving with greater velocity than the inner, being farther from the center of rotation. Thus they are forced to whirl about their own center, and the Rotating Body throws off another Rotating Body through its centrifugal energy, which new Rotating Body may repeat the process.

Thus we have reached the point at which the Rotating Body becomes self-generative, that is, it produces through rotation another of its kind, which in its turn may reproduce itself. The moving Body has now engendered a motion which no longer pulls it to the center, but throws it off from the center; gravitation has turned into a kind of degravitation. This is, therefore, the conclusion of the Gravitating Body with whose simple fall earthward in a straight line we began, and which next showed its fluctuation between the two opposing forces in the oscillation. The latter, however, completes itself in the Rotating Body, which still clings to the one center under ordinary circumstances. But if the rotation be increased up to a certain point, the Rotating Body divides within itself and becomes two or many Rotating Bodies which form or may form a system.

Still each of these Rotating Bodies, revolving on its own axis as a self-contained whole, is subject to gravitation, which is not destroyed by the new axial motion of the separated Body. To be sure the moving Body no longer merely falls, or oscillates, or rotates, in and by itself; it gravitates still, but also it keeps flying tangentially, preserving likewise its axial motion. Thus it moves in a circle or orbit around its central, or originative Body.

But with this system of axial and orbital motions of Bodies, we have quite transcended our terres-

trial limits and have really entered the field of celestial mechanics. The Particularized Cosmos with its manifold collisions has passed into a new cosmical order. The Moving Body with which the Particularized Cosmos started as something given, has unfolded to the Rotating Body which now generates the Moving Body culminating in itself, that is, in the Rotating Body. Thus the process of this second stage of the Cosmos which we call particularized, has rounded itself out to completion. The Cosmos as incorporate now reproduces itself as Body without collision.

A physicist of authority has made the calculation that if the earth were to revolve seventeen times faster than it does, a Body at the equator would not weigh anything, would not fall, but would remain in the balance as it were between the so-called centrifugal and and centripetal forces. Terrestrial Gravitation would be just counteracted by terrestrial Rotation. According to this reckoning, if the earth's revolution were made greater than seventeen times its present velocity, objects on the surface of the earth, perchance people, you and I, would begin to rise unwinged and to fly off into space. Moreover we would spin, each turning on his own axis. We would be transformed into little planets, or rather satellites, which might circle about mother earth in an orbit with axial rotation like the moon. We might re-enact the original world-making of the solar system, which,

as we shall observe later, is supposed to have been thrown off by the primeval sun unfolding out of its nebulous condition. But without passing through this dubious if not dangerous process, we can at our ease behold a little miniature of globe-producing in its evolution and revolution by looking at a stone as it whirls from the rotary motion of a sling.

Already physicists have taken pains to observe and to measure the different velocities of the fall of a Body in differents parts of our earth as an oblate spheroid. At the equator it is 32.09 feet a second; at New York 32.16; at Spitzbergen, nearer the pole, it is 32.25 (Ganot). Thus the Body diminishes in weight as it gets more distant from the earth's center. If it were borne outward in space toward the moon, at what point would the terrestrial and lunar attractions for it equal each other—and what would then happen? The problem may be pushed further, even to the boundary line of the Solar System, on which line we may conceive a wandering body to be balancing, hesitating whether to go out or to stay in. Alpha Centauri is said to be the nearest star, and is larger than our sun, and so is endowed with greater power of Gravitation. A fence between the possessions of these two somewhat grasping neighbors must run somewhere through the cosmical spaces, and there are stray bodies or tramps of the skies which climb over it from one celestial farm

into another. Seemingly some comets do so, and doubtless vast hordes of invisible, yea microscopic migrants cross the limits of systemic Gravitation, and interconnect the stellar provinces of the Cosmos.

We have seen that the Rotating Body when brought to rotate at a certain velocity becomes reproductive and begets itself. Motion has the power of dividing Matter at a given Measure, reproducing bodies, or in general the Particularized Cosmos. The interest here is to note that the three primary cosmical elements—Motion, Matter, Measure—are perpetually bringing forth through their own process the vast variety of the corporeal world. Undoubtedly the turn at which the velocity of Rotation becomes productive must vary a good deal on the planets and throughout the physical universe. We have already noted the point at which the earth's rotation might start to generating new earths even if small. In this connection we may observe another fact for the future: the spin of the stone is in the same plane as the whirl of the sling; the rotation of the generated body in the main parallels the rotation of its source. This fact holds of the planets and the satellites (with a few curious exceptions), and will some day probably be shown to hold of the Sun himself, which may have been once, with the other stars, thrown off from the rotating Cosmosphere.

Rotation has a radial energy, striving to ray out

in opposition to Gravitation, to the very limits of the universe, according to the velocity. It would seem therein to suggest already in Mechanics the radio-active principle generally, such as Light and Heat (not to speak of radium itself). The thought will rise that the limited Rotating Body urged to the top of its speed, will expand toward the unlimited, will seek to universalize itself, will radiate from its center as if striving for luminosity. Such is called its centrifugal force and hints already in the Cosmos the counter energy of the Diacosmos. Rapid Rotation tears even the cohesive fly-wheel to pieces and rays them out like light-balls, prophetic of the coming phase of Nature.

We may go back again and take another look at the fall of the body to Earth which stops it indeed, yet carries it on in a circle of motion, which really completes its partial rectilineal descent. Using the word freedom in this connection, we may say that the fall of the Body to the earth is but half-free, while by its sweep with the Earth it shares in a fully free self-returning round of motion. And still further might the thought be carried till the falling Body participates in the All.

The oscillating Body should also be glanced at in a retrospect before leaving the present sphere. It images the oscillation of the moment, of the day of the year, of the period, yea of Time itself. But the oscillation is partial, is only a stage, and when it becomes total it must supply its other part and

become rotation, which in its wholeness reaches back to the beginning and forward to the end.

We may return once more to the Rotating Body, seemingly the first form of the physical universe. But on the earth this rotatory movement is still under the control of terrestrial gravity which will finally stop it, and also will pull down the generated Body also rotating. Still, when the rotation is adequate to throw off the new Body to a sufficient distance and to impart to the same enough rotation to keep it spinning, then it obtains a new motion which is orbital, and to its own rotation is added its revolution around its original central Body. Such we may take as the first glimpse of the System which is next to unfold in the Cosmos, and to give to the same a new and more complete manifestation.

CHAPTER THIRD.

THE SYSTEMIC COSMOS.

We have now reached the Cosmos as systemic, or as the cosmical system of Nature incorporate. Motion and Matter are brought into an harmonious order, or at least relatively so; the collisions which we have just witnessed in the Particularized Cosmos, are mediated in the interest of an universal order whose stress is to avoid the conflict of Bodies through a system. The force of gravitation still holds and pulls the Body in a straight line, but the force of rotation enters and compels a circular movement around the material center, thus shunning the clash of worlds. To be sure the cosmical collision may not be wholly avoided, but it is now pushed into the background, being usually relegated by the scientific theorist into the remote past or remote future, when the Sun himself shall die.

The fall of a Body, if it be conceived as universal, comes back to the beginning; it falls into itself, so to speak, and keeps on falling thus. The Body through Motion is continually brought afresh to its start and persists in going its round; Motion incorporate has become cyclical, it is no longer stopped and dragged down by Matter, but picks up and carries its Matter along in its circle. This

we may regard as the triumph of Motion over Matter, while in the Particularized Cosmos the triumph was the other way. We may deem it the inherent necessity of Motion, as sprung of the All directly, to complete itself, to make itself a whole, that is, a whole in itself. So it evolves through its stage of finite and particular Motions, and at last gets around to the point of its own beginning, whereby it becomes endless. As a rule the Systemic Cosmos is a vast and intricate complex of rings of Motion which sweep about the central Body in many shapes, more or less elliptical. The typical form is the Solar System of which we are a part, but probably each self-luminous star is the center of another such a system. The celestial world, even in its wildest cometary and nebulous appearances, is a world of system whose law, if not yet found, is always sought for with the certainty of its existence; astronomy means literally the science of the laws of the stars. Moreover these laws are laws of the harmonious movements of Bodies rather than of their collisions. Again we recall the old conception of the harmony of the spheres, going back it is said, to ancient Pythagoras.

The Cosmos emerging from the chaos of terrestrial conflict which we have just seen, rises into the realm of celestial order, and systemizes itself; this is now its essential fact and hence it can well be called the Systemic Cosmos. If we consider in thought the falling Body, it must have been forced

into its condition of separation, which it seeks freely of itself to overcome, thus returning to its origin. It tries to circle back to its beginning, but this the interposing earth prevents, though the striving remains. But let the earth be conceived as taken away; or rather let the earth itself be conceived as the falling Body, which must perpetually fall towards its source whence it has always to begin over again, being as Body separated therefrom primordially. The earth falls freely toward the sun which was probably its material source; but as Body separated it is turned away, the original separation being continually re-enacted once every year. That is, the earth-child hastens back into the warm embrace of its sun-mother for a rejuvenescence or new birth; but being re-born, we may think, from its primeval womb, it is ejected again into space on its annual round till its striving wheels it about once more, after its winter of alienation. This renewal of our planet's birth by the sun is ever repeated, and constitutes its chief period, called the year, verily the type and indeed the ground of all other periods. Moreover we behold in it an outer cosmical image of the inner process of the self, separating from and returning to its germinal source. To be sure the sun-mother herself we shall likewise find to be a Body separated from a far larger totality, to be a child of the greater Cosmos, having probably its round also, and circling through untold æons. Still

even the Pancosmos, if so we may call it, is a separation, indeed it is just the Separated originally from the All-Self.

In such fashion we seek to glimpse and to express the inner psychical movement of the visible Systemic Cosmos. But there is another expression very different, the mechanical, which was and is still found in the science of Astronomy. Laplace, echoing his time, calls his great book *Celestial Mechanics*, and declares in the preface to it that "Astronomy, in its most general form, is a great problem in Mechanics," whose given elements are the movements of the heavenly bodies. Yet Laplace, as already noted, gave a start to the genetic or evolutionary theory of the Systemic Cosmos, Kant's similar view being quite unheeded though prior. But it was Sir William Herschel, the contemporary of Laplace, who in his observations on the nebulæ of the Heavens laid the material foundation for the new Astronomy, which deals so largely with the origin and development of the stellar world. In accord with the spirit of the Nineteenth Century the science of the stars has become decidedly evolutionary, of course without giving up its previous mechanical acquisitions.

Already we have given a brief account of the nebular hypothesis as unfolded by Kant and Laplace (see preceding pp. 29-31). It is an interesting fact that this hypothesis, which started as mere fanciful conjecture or idea, has been clothing itself with re-

ality more and more till at present it is the dominant theme of astronomy. Again we see the thought going in advance of the thing and forming a center of correlation for the phenomena of the new science. Physical and astronomical discoveries have indeed much expanded and developed the orignal nebular hypothesis, but it still remains the core around which fresh facts gather themselves and get ordered.

The old Astronomy was largely mechanical or cosmical; Motion and Matter it indeed ordered but chiefly through Measure, and thus it showed the triumph of Mathematics. The new Astronomy is rather physical or diacosmical, though it does not dispense with Measure by any means. Still the nebula has in most respects eluded measurement hitherto, though its turn will probably come.

I. The nebula, then, is the central phenomenon of astronomy at the present time. It brings up the question of the origin and the development of the entire physical universe. It may be here said that the naked eye is of little help in finding the nebulous shapes of the skies. A powerful telescope is required to bring them out of the spatial depths in which they are hidden. Sir William Herschel with his huge instrument of remote vision was really the first who caught sight of a large number of nebulæ and began their systematic observation. He also spoke the pivotal word about them; he declared them to be various stages in the evolution

of the Cosmos. In the far-off Heavens men began to see the genesis of the Sun and its system, yea of all cosmical systems. It was soon observed that the nebulæ had many sizes, forms, gradations; each became a leaf in the long history of world-making. A search started for the intervening steps between the thinnest distant nebula and our own solid earth.

But the human eye looking through a powerful telescope was discovered to be inadequate. Upon a new kind of retina, far more delicate and penetrating than the ocular, celestial objects were to impress their images. The photographic plate was this new organ of sight which, with its greater sensitiveness to light, began to reveal the mysteries of the skies hitherto unseen. In this work the Lick Observatory on Mount Hamilton, in California, has been specially successful by means of its large telescope of three feet aperature, known as the Crossley Reflector. The late Professor Keeler, who devoted himself to photographing nebulæ, advanced our knowledge of them enormously He continued to discover them till he estimated their number at 120,000 within reach of his telescope and his photography. Here is an incident which he records in his experience. He adjusted his instrument to take a copy of an important nebula in the constellation of Andromeda; behold, when he looked at the photographic plate, he found not only what he sought for but thirty-one other forms of nebulæ.

Nor is this all. Upon the plate he noticed numerous small light-points the nature of which even the Crossley Reflector could not unravel, but which he conjectured to be nebulæ still more remote. Thus these nebulous shapes stream out into regions beyond the stars, perchance beyond the entire galactic system, which we see circling our Heavens. They suggest other cosmical systems. Moreover, they seem to form a common connecting body or element interlinking the total physical universe. There is getting to be at least a conjecture that the nebula is not far removed from the first elemental Matter of the Creation, possibly being next after the primal ether, of which we are hearing so much in these days.

In this connection may be noted the triumph over another difficulty pertaining to the nebula. Cases repeatedly occur in which large telescopes resolve into individual stars what appears a nebular mass when looked at through smaller instruments. Accordingly the inference stands near and has been made that all nebulæ are ultimately star groups closely clustered, and are destined to be resolved when the telescope grows more perfect. Still there remained many of these bluish fog-banks of the skies which the best instrument might magnify but could not turn into stars. Finally the spectroscope came and was applied to these nebulous masses. The result was that the spectrum of a true nebula, though varying in itself,

was found to be distinct from the spectrum of a star. Such is the decisive test which even the photographic plate through the telescope could not give. It is acknowledged that the true nebula is composed of a gas heated to incandescence, while the star is a body more or less solidified, likewise incandescent. Now if the light of an incandescent solid be examined its spectrum is continuous, showing all the colors of the rainbow in their succession. But the spectrum of an incandescent gas is called discontinuous, showing bright lines upon a dark background. So with the aid of the great telescope, of photography and of the spectroscope, we have reached back to a primordial gaseous Matter, quite formless as yet and incohesive, but starting to show itself, that is, to be self-luminous.

It is to be noted that the three mentioned instruments—telescope, photographic plate, spectroscope—depend upon a single physical medium, light. They are the human eye indefinitely extended and intensified, within whose natural range they bring the sheen of far-off and otherwise invisible worlds. Through this light all matter begins to become self-revealing, it starts to tell on itself with a still small voice reaching through immeasurable distances. At a certain point of heat usually, body commences to show itself, it is endowed with a kind of impartation. Light we may deem the cosmical language in which each visible member of the universe talks a few words to all the rest.

What does the nebula say by means of its faint though varying illumination? It gives some flashing hints of its position in the heavens, of its size, of its density, of its subtle tints. Light, accordingly, bears a message, we may say a revelation from its nebulous source. It communicates knowledge, which will probably be much increased when we understand the language better. Light is a sort of intercommunication between the individuals of the Cosmos, and brings them into a kind of association, making them at last a single community.

But the chief thing which light has revealed as yet concerning the nebulæ is their form which is of great diversity and of many gradations. It is the study of these peculiar nebulous shapes with their co-ordination which suggests the evolution of the Cosmos.

II. It is worth while, therefore, to look briefly at certain special nebulæ in this vast multitude, for the fact is that they often show a distinct individuality in shape, in size, in density, and even in shades of color. There seems to be a pretty general consensus of investigators that the Great Nebula in Orion, as it is called, gives a characteristic starting-point in the evolution of the Cosmos. First of all we may regard its shape as revealed in the photograph of the Lick Observatory. Irregular, raveling out around the edges into thinnest gossamer shreds, with a heavy bulge or wart on its

back, it seems to be struggling toward a form more circular. As to size it frays out indefinitely into space; each new power of the lens brings into view slight filaments previously invisible. On the whole it appears to be pulling itself together out of the unseen elemental Matter, and to be slowly getting self-luminous through an increase of heat. By the way this heat, so common about us, is a very significant factor in world-making, a kind of formative energy throughout the Cosmos. The extent of the Great Nebula in Orion is, therefore, immeasurable, and evidently not visible. But the image of so much of it as can be thrown on the photographic plate can be vaguely sized. An English astronomer, Prof. Ball, has estimated that its area would easily enclose a million of our Solar Systems, as bounded by the orbit of Neptune—that is, the area of it so far as this is reproduced in the Lick photograph.

At the view of such a huge object one gets contemplative, and begins to inquire: What is here in the making? Not a planet, not a sun, not even a Solar System probably; all that seems too small for the outlay. The imagination stretches itself to its limit and conceives of a new stellar world in the process of formation; another encircling Milky Way (or Galactosphere) we glimpse in its earliest visible genesis. For our sun is only a star, and a rather small one comparatively, of that rounded Galaxy which we behold in the sky bend-

ing over us; millions upon millions of starry members it has in its colossal circle which on its part may be also revolving about its center as yet totally unknown. So this Great Nebula of Orion, not yet rounded, but seemingly rounding itself and raying out beyond the ever-extending clutch of the largest telescope, may be taken as a kind of prelude to the new cosmogony, the evolutionary as distinct from the old ones, in which the world was directly made by the fiat of an Almighty Will. We may state, however, that this act of Will cannot be put out of universe.

It need hardly be said that the most slender film of gauze belonging to the Great Nebula of Orion is something derived, it has an antecedent from which it sprang. Even if its antecedent be, at one or more removes, that primeval omnipresent, but elusive ether, which no man has yet seen, felt, or pinched with an instrument, still this ether must also go back to a creative source. At present, however, we are studying what seems to be the first sensible appearance of the visible universe, a primordial fire-mist with its faint light.

Moreover, we have to think that these nebulous masses are in motion; in general these shapes suggest that they are undergoing some sort of transformation, though of course we cannot see them moving. And we can have little doubt that their movements are more or less circular, they are turning on an axis in some way. Motion we

have seen to be the first-born of the Cosmos, before even Space and Time, or rather along with them; the earliest Matter will be endowed with Motion and doubtless with round Motion. In the real nebulæ we may premise that we have begun to see the primal visible Matter, though the Motion of it has not yet been detected. Note it is this Motion which is to become decidedly explicit in the course of cosmical development. Our Solar System was once a nebulous shred, doubtless revolving; its Motions have become the prominent thing in its present appearance. Not merely an evolution of the Matter, but an evolution of Motion astronomical science is to reveal. In Cosmology we have to work backwards from our present Solar System to or towards the beginning which is literally nebulous. The planets and their satellites are conceived to be products of a rotating Heliosphere, which throws them off while imparting to them its own rotation.

In the process of world-making we trace by the variation of these vast fog-shapes the cosmical development. If the Great Nebula in Orion has the appearance of trying to pull itself together, there are other nebulous masses which show no such striving for unity, but which seem scattered about wholly decentered. It cannot as yet be told whether they are going out or coming in, worlds vanishing or arising, though Mr. Lockyer thinks that he has found a partial test for ascer-

taining this fact, whereof mention will be later made. ' Some shapes seem strongly centered but irregular, as the Crab Nebula; not a few are ring-shaped like the felloes of a wheel (in Lyra); others divide from the center like the spokes of a wheel (the Trifid in Sagittarius). Nebulæ show a tendency to assume round shapes, though these too are very diverse. Still there are rectilineal nebulae or those which seem such, for this fact cannot always be verified; at so great a distance the round edge may appear a straight line.

Some nebulæ are therefore, unformed if not formless; others seem to be forming, or in some stage of formation. It would appear that they have in general a formative type toward which as an end they are moving and which they are seeking to unfold to fullness. Now what can we consider to be that final form of itself which the nebula is striving to reach, and toward which the paths are so diverse? Taking the criterion of form as marking the stages of its evolution, it can be said to show a final form, a last phase ere it passes out of its nebulous state. This ultimate form of the nebula, even if it has many gradations within itself, is the spiral, which on account of its place and importance should receive some special mention.

The great pivotal fact, accordingly, in the unfolding of the nebula is that it beomes a spiral, which may be deemed a cosmical stage quite ad-

vanced, but by no means as advanced as our Solar System. In comparison with it, however, the Great Nebula of Orion just considered seems quite primeval and chaotic, though it too shows a tendency apparently to draw itself together into a round form. Other nebulæ look like hazy balls, but they are all probably flattened like the earth at the poles. That would follow from their circular movement. But as they are of gas and not even a liquid, this flattening must be much greater than that of the earth. The spiral nebulæ are naturally flattened, which condition is the forerunner of this spirality, or of their separation into the whirls like those of the ramshorn.

It so happens that the spiral nebula has its most striking representative in the photographs of the Lick Observatory. The object is found in the constellation known as Canes Venatici, not far from the first star in the handle of the Big Dipper. The photographic image of this nebula makes it appear similar to a very agitated maelstrom whirling off a huge planet or perchance a total system from the end of its outer spiral, while the rest of the same spiral is breaking up into separate pieces. In fact the whole coil is dividing within itself as if getting ready to fling its fragments outward into space as independent bodies. Moreover the center of the spiral has become more condensed and more luminous than the other parts, though these differ from one another in density and luminosity. The

whole picture compels the idea of a central sun in the making, perhaps several of them, with their planetary systems. The size of this great spiral nebula is not ascertained, but it has been supposed to be thousands, possibly millions of times larger than our sun and planets. Still it requires a telescope to find it, and the best sort of an instrument to show its details. Lord Rosse first detected and described its spirality, but the correctness of his observation at first met with a good deal of incredulity even from astronomers.

Recently the fact has come to light that fully one half the 120,000 nebulæ now supposed to be within the telescopic field are spiral. This is the estimate of Professor Keeler. If such be the case we behold so many systems throughout the Heavens in process of evolution. Moreover the spectroscope has been invoked to give its evidence concerning these spiral nebulæ. Judged by their spectra they are no longer gaseous; they have developed out of the vapor of the Great Nebula in Orion and its kindred. Spirality may, therefore, be taken to represent a very pronounced condition of cosmical development; the nebula has advanced to the point at which it begins to show its separation into the members of a system, like that of our sun with its planets and their satellites.

It must not be forgotten that spiralism takes many shapes; the 60,000 of them, more or less, numbering as many as all the other cruder forms

combined, cannot be yet classified. Indeed astronomers are coming to believe that there are more spirals than anything else in the celestial strata. It is probable that the spiral period of a nebula lasts millions of years. The order of evolution through these primeval ammonites of the skies is not yet ascertained; but that they unfold in a succession of aeons is scarcely to be doubted. There is still to be the uranology above corresponding to the geology below. The form-test, which has been given here, is hardly sufficient by itself; the density, the degree of luminosity, the color, the spectrum of the nebula, are all bringing a message which has not yet been deciphered, still less has it been organized.

Moreover different spirals seem to be evolving very different kinds of systems. The smallest and nearest may be turning out little suns such as ours with their petty planetary followers. But the gigantic spirals like that in Orion or in Canes Venatici are surely not engaged in such an insignificant piece of business. They are evolving whole constellations, systems of systems, perchance an entire Milky Way. As far as our vision can reach, we have but the one Galaxy, though there may be many in starry bloom, while others may be arising out of the vast nebulous masses, and still others vanishing through a colossal fog-world. The life of a system, the life of a star, even the life of a planet cannot of course be deter-

mined, still the beginning has been made when they are conceived to have lives or to be passing through a cycle of evolution.

III. We are now ready to consider the application of this nebular evolution to our Solar System, which, we must first observe, has developed far beyond the spiral nebula. Yet we conjecture that our sun and its planets had once the shape of the spiral, like that seen in Canes Venatici, and like thousands of others scattered through the heavens. The primeval fire-vapor began to throw off its heat into the circumjacent space, and thereby to contract. Moreover the vast mass broke up into smaller masses, each with its own center, as the contraction went on. The middle portion of the nebulæ, however, still remained and would start to revolve more rapidly than the portions on the rim, which gradually obtained their own separate motion. Thus the spiral produces the planet and imparts to it a rotation which becomes its own. The center is a kind of whirlpool with an ever-increasing velocity, as it grows less in size, through the dissipation of its heat. In this way our sun is conceived to have been slowly transformed to its present condition, which is still that of an intensely heating body with the corresponding radiation. The planet, being much smaller will cool more rapidly, and pass from a molten liquid to a solid, at least on its surface. Such is the present state of our earth, whose interior is still

supposed to be in its original igneous condition. In llke manner the other planets have been whirled off from that primeval spiral whose age reaches back many millions of years. The process of cooling is still going on, both in the sun and the planets, and the question is much discussed whether their heat will fall below its life-giving power.

It should be further observed that the planet also became the center of evolution, and unfolded its own system of revolving bodies called moons. Thus the systemic order repeats itself; the whole is reflected in each of its parts. Or we may say that each part, in order to be a part of a whole, must have within itself the process of that whole. So the planetary part, in order to remain a part of a system, must repeat the process of such system. And yet further we have to push the thought. The Solar System is a part, and only a very small part of the total Cosmos, yet it reflects the universal order. Astronomers quite generally take for granted that the stars are suns, each of which has its family of planets. So a system runs through the entire physical universe, a common ordering principle, of which our little system is a reflection, a particular manifestation. And still further we may glimpse the working of the All, and forecast that this same physical universe as a whole, and not simply in its parts, will be found to be the original model or creative prototype of

our System and of all others, in fine of what we here call the Systemic Cosmos.

It is generally considered that our moon was once a part of the earth, but a rift occurred while both were in a fluid condition, when they were forced further apart by the action of the tides into their present orbits. The mass of the moon compared to that of the earth is about one-eightieth, making it altogether the largest satellite relatively, either lunar or planetary. The mass of the sun for instance is 800 times more than that of all the planets together, and the largest satellite of Jupiter is more than 10,000 times less in mass than the planet itself. Our moon seems to have united into one huge body comparatively what elsewhere separated into many small bodies in the evolution of planets from the sun as well as of satellites from the planets. In this regard our moon is a striking exception in the Solar System.

We may consider the evolution of the sun, planets and their moons from their primeval nebula as the evolution of the Heliosphere. This is supposed to be at present in its bloom, if not verging toward its decline. Some scientists suppose that quite one-half of the sun's thermal energy has been already dissipated into the space outside of the system. What, then, lies before us? This topic will recur in another connection.

IV. We can now see the genesis of those two forces—centrifugal and centripetal—with which

Newton sought to explain the orbital movement of the Earth around the Sun. At present they are rather discredited; really they do not explain, but introduce a new difficulty, for they are in themselves contradictory at the pivotal point. Each has to turn into the other just when it ought to go the opposite way. Moreover, the fact is that the so-called centrifugal force is properly tangential, but is deflected at every point into a curve by Gravitation. We may conceive, therefore, that the circular movement of the earth in its orbit is the resultant of Rotation and Gravitation continuously working and combining along with momentum to one effect.

Orbital circularity is, accordingly, an ever-present process between Matter gravitative, and Motion rotative. The earth as eject of the whirling sun, also whirls and moves away by itself; but as material it is still drawn by its powerful ejector. The outcome is the terrestrial round, always returning into itself at every point. The strain for unity and the strain for separation results in a movement which keeps forever separating, yet coming back.

It is said in the books that the greater the velocity of rotation, the greater the centrifugal force, which is declared to be "proportional to the square of the velocity and inversely as the radius of the circle described." Rotation in general has the tendency to tear asunder the body and to fling from

the center its fragments, which also rotate. In this sense rotation may be conceived as the immediate genetic act of Matter, in which a body is compelled to beget other similar bodies through Motion—the creative, or here the separative principle, being itself just the Separating of the primordial Cosmos. Undoubtedly cohesion varies the point at which this material fissipation takes place; but the most cohesive body will at last yield to rotatory speed and fly apart into new bodies, which may become a system.

The Earth was thrown off by rotation from the revolving Heliosphere as nebula, and was endowed with a rotatory movement of its own. The physical cause is that the outermost rim or layer moves faster than the one next to it and so on till the center. This difference of speed in the adjoining parts must force them asunder if the speed be sufficiently great. The one part or particle goes faster than the other and must leave it if the rotation be increased. Of course the line of cleavage of a mass will be found at some stratum of weaker cohesion. Moreover, the separated body being still material and extended, will have different momenta on the outside and on the inside; the outside layer moving more rapidly will pitch downward and start the whirl. So we have already seen the stone spin from a sling on the earth's surface.

Rotation is, therefore, the differencing principle of the Systemic Cosmos; it separates and then in-

dividualizes cosmical bodies, endowing them with itself, namely, Rotation. The primeval revolving Heliosphere of nebula has evolved and organized itself through this principle into the present Solar System. And there is little doubt that the separated nebulous Heliosphere goes back to its unseparated period in some far greater mass, probably like the spiral of Canes Venatici. On the other hand Gravitation remains the unifying principle and works in counteraction of Rotation. Such is the dualism which has been uncovered in the Systemic Cosmos, this being at bottom the process of these two opposite energies always forming a third and thus reconciling their dualism. Indeed we may trace back the foregoing opposites, Rotation, and Gravitation, to the primal elemental dualism of the Cosmos, Motion and Matter, out of which Descartes would construct the physical universe (see preceding p. 39). Of course the Systemic Cosmos shows these elemental forms more highly evolved, in fact realized.

The original forces which threw off the planets are still at work; the sun continues both his Gravitation and Rotation. No planetary body falls back into the central luminary, which attracts and then repels its children. When they come into its sphere of Rotation, they are ejected anew (in perihelion); but as they recede, the influence of solar Rotation grows less, and Gravitation relatively increases, till repulsion changes into attraction (in

aphelion). The Rotation of the sun exerts a perennial power as well as its Gravitation; the planet does not have to be conjoined to it in order to experience the centrifugal influence of its Rotation. Thus the planet with its momentum is under the sway of two opposite solar forces. The rotating planet preserves its separation, or its individuality, through the rotating sun, which is always begetting it anew.

Unfailingly the question springs up concerning this Rotation, which seems to be something primordially given, or coming in from the outside. The rotating Heliosphere has to impart its gift to its planetary offspring, who in turn transmit the same to their satellitic children. Even the little terrestrial pebble may share in it for a brief moment under right conditions. But whence does the Heliosphere get it? Seemingly from a still vaster rotating body which on its part must have received it from a yet more primordial source, possibly from what we may conceive as the Cosmosphere. And still the search for the source is not quieted. Original Motion must have been Rotation, the primal utterance of the All-Self in Nature, of that which we have repeatedly named the Pampsychosis, which is within itself this entire process, now appearing external and visible in the Systemic Cosmos. Rotation has thus a marvelous pedigree, coming down from the First Motion through the entire physical universe and clothing

itself in manifestation from the largest nebula to the smallest speck of dust.

V. The enormous projective power of rotating spheres in the period of world-making has been shown in the calculations of Mr. G. H. Darwin, (son of the great founder of evolution) who states that some 54 millions of years ago the Earth made a complete revolution on its axis in three hours. It was then in a liquid state, and from its equator threw off the moon, which also revolved in the same time. Such was the Earth's primal creative act of Rotation; it begat another Earth rotating on an axis. But Gravitation did not fail; the mighty tangential outpush was deflected into an orbital motion, and moreover each body being liquid produced tides in the other, which acted as a brake upon its rapid Rotation. The moon is still exerting that brake in the terrestrial ocean, causing the earth to revolve slower and consequently making the days longer. The same author estimates that our day must continue to lengthen until it is 70 times what it is now, until there are about five and one-fourth days in the year. But for this consummation 150 millions of years will be required.

Can a tangential force on the surface of the Earth be artificially produced, which will equal gravitation and unite with the same in an orbit? A mathematical calculation has been made that a ball fired horizontally from the top of a mountain

at the rate of five miles a second would pass round the globe, the resistance of the air not being counted. This is seventeen times faster than the rotation of the earth at the equator. Such an object would be in effect another moon, and prompts the question whether man is yet to become the maker of his own satellites. It is also calculated that a projectile hurled upward at the rate of seven miles a second would overcome terrestrial gravitation completely and fly off into space without return. Evidently the Moon was detached when the Earth was just at the right velocity to throw it off by Rotation yet to keep it also by Gravitation. The three elements of the genesis of its completed motion—rotatory, tangential, and gravitational—were all united and reconciled in its system.

As the Moon and Earth are both independent bodies, each has its field of gravitation, between which a boundary must be conceived. This also has been drawn in exact measurement. The mean distance between the two is 238,500 miles; the line of separation runs 22,800 miles from the Moon, and 215,700 from the Earth. A projectile shot toward the Earth from the Moon at the rate of a little more than a mile and a half per second would cross the line, while in the opposite direction more than four times as much speed would be required. If Terra and Luna ever get to bombarding each other, we on our side shall have to burn more powder.

The problem of running boundary lines between systems is one which astronomy has hardly yet grappled with seriously. Gravitation is supposed to cross these lines, and yet with a certain limitation of its power at the frontier. Light certainly is not stopped by them, probably not Heat. If Rotation be an influence which extends beyond the body rotating, is it the force which is halted at the border and turned back upon its own system, thus delimiting the same? The original nebula of our Solar System is supposed to have extended far beyond the orbit of Neptune, as yet our farthest planet, and it may have reached to the aforesaid boundary line. This vast nebula must have revolved as a whole and thus have marked out its primordial limits through rotating on an axis. This Rotation is still practically kept up by the rotating uniformity of the sun and planets in the position of their planes, in the direction of their motions, and in the inclination of their orbits. There rises the further question, Is not the whole system still rotating in its flight through the skies?

Our Sun is a star of the Milky Way; we call it a body of the Galactosphere, and hence of the Cosmosphere. The nearest star to it is Alpha of the Centaur, whose distance from the sun has been calculated to be more than 9,000 times the radius of the orbit of Neptune, the outermost known planet of the Solar System. This vast tract would seem to indicate the manner in which the stellar

systems are separated and are given their own field of operations. The great distance lessens though it does not destroy the force of gravitation between the two central suns, each of which can thus control its planetary sphere without much interference. A peculiar fact about this next neighbor is that it is a double sun, each solar member revolving about the other at a distance which is estimated to be a little greater than that of the planet Uranus from our sun. The mass of Alpha of the Centaur is considerably greater than that of our sun, and hence has a greater power of attraction; still the two systems are relatively independent. In a direction toward opposite is the second nearest neighbor, 61 of the Swan, also a double star, whose distance from us is set down at 43 billions of miles. On this side, then, lies a still broader belt of separation. Our system and that of Alpha of the Centaur have thus a proximity, which probably has its past history reaching back to a common primal nebula, and which may have a future history when both have dissipated their heat and light and have become floating corpses ready for a new transformation.

The sun with its retinue of planets is also moving through space, doubtless in an enormous orbit, whose curvature is so slight that it has not yet been detected. But upon this subject the observations are very recent. The solar system is said to be sweeping toward Vega of the Lyre at

the rate of 400 to 500 millions of miles a year. Different astronomers give different stars as "the apex of the sun's motion," or the point toward which it is making; but the present scientific consensus seems to be fixing upon Vega. So the broad tracts ot celestial separation are traversed by systems surging in every direction, probably in orbits, but some observers say in right lines. Will these bodies ever collide? That, indeed, has been and will continue to be a puzzling astronomical problem, in spite of the assuring calculations of Lagrange and Laplace.

If our sun is moving in an orbit around a center and the other stars are doing likewise, the question rises concerning the character of this center. Some have supposed that it is not luminous, but is an invisible dead mass of matter of enormous proportion keeping the universe in order by gravitation. A recent astronomer, taking as center a point near the orbit of the double star 65 of the Fishes, has calculated the time of a complete revolution of the solar system, which he makes twenty millions of years. Every star in our universe (seemingly in our Galactosphere) is regarded as moving about the same center, forming one stellar or rather galactic system—the unification of all solar systems, estimated at a hundred millions.

Coming back to the systemic boundary line, we may note that astronomers have drawn it between our system and that of Alpha of the Centaur at

114,000 astronomical units distant from our sun which once had on that line its primal nebulous border. Adjoining it and probably one with it was the nebula of Alpha of the Centaur, which has now solidified into a binary sun at a distance of 161,000 astronomical units (this unit is the average distance of the earth from the sun used as a unit of measure for very great distances). If this measurement be correct, on the side toward the nearest stellar neighbor our known planets do not extend their orbits to hardly more than one four-thousandth of the distance to the boundary line, Neptune being only 30 astronomical units from the sun (out of the 114,000). One speculates about what is playing in that vast space. Is it empty, a mere deserted borderland between two systems, which are thus kept asunder lest they might lock horns. Many comets doubtless lurk there till they return to the sun. Unseen planets have been and still are supposed to be circling around our central luminary in vast orbits through that seemingly unoccupied domain, though it is under solar control. Indeed three extra-Neptunian planets have been heralded at different times, but they have not yet been seen. One of these was placed at a distance of three hundred astronomical units from the sun, ten times further than the orbit of Neptune.

The next stellar neighbor on the other side of our system (61 of the Swan) is toward twice as

far away as Alpha of the Centaur, and furnishes a harder problem for those who would try to run its boundary line. We may see, however, that the sun with its known planets takes up but a small area of its total spheral influence, constituting a little circular disc, as it were, in the heart of a huge surrounding globe of space. Indeed the entire Heliosphere may be regarded as a molecule of the Pancosmos, a petty globular pellet which is organized with its own whirling atomic system at its center. This conception of the cosmical molecule we shall find reproducing itself under various forms in the recent view of matter, whose atomic constituents, though invisible, are held to be, each of them, a system of corpuscles or electrons, which are rotating in their own space within the limits of the atom. Thus the Solar System becomes a kind of center for illuminating not only the infinitely large in the stellar world, but also the infinitely small in the atomic world. The organization of the Cosmos is in this way being transferred to the organization of the Diacosmos.

VI. The nebular theory in its latest phases may be supposed to account for the evolution of a sun and its planetary system out of the primeval fire-mist. But evidently this is only one segment of a great cycle of evolution; so we cannot help asking after the complementary segments. This self-luminous nebula with which we have to start, since it strikes for us the first light—whence does it come?

Then, after we have seen the sun (or star) with its system evolve, what is its evolution through the millions of years? For it evidently does not stop unfolding. It would seem to have its birth, its culmination, its decline and death. Can the stages of such a stellar life be observed and the various stars be classified as young, middle-aged, old? Thus the firmament will be filled by an æon-lived population analogous to our year-lived humanity.

The first fact was one which has long been observed: the difference in color among the stars. Some are red, some are yellow, some are white with many intervening gradations, embracing all varieties of the spectrum. If an iron bar or poker is heated to incandescence, it is at first red, then yellow, till it reaches white. Evidently these colors depend upon the degree of temperature. As the stars have metals in their composition, and are probably the original smithy in which metals are not merely forged but actually created, the analogy of hot iron has been transferred to them. The stars show different degrees of temperature and in accord therewith different stages of life. They are increasing, culminating, declining in heat or energy, and so represent the various stellar life-periods.

It is plain that a difficulty appears at this point. Is the given star, observed just now as having a certain color, rising or falling in heat—is it on the

ascent or on the decline? Arcturus, for instance, has a yellowish intermediate light—is it moving up or down the scale? For the body, getting hotter goes through the same gradation of colors that it does in getting cooler. Sir William Huggins, the pioneer in this field, says that the primal stage of a star is bluish-white, then passing to white, yellow, red. The classification of stellar spectra into types was first made by Secchi, but his work was modified by others, especially by Vogel whose three types are now commonly accepted. These are as follows:

(1) The hottest stars: gaseous, longest spectrum—hydrogen and helium, intense bluish and white light.

(2) Less hot: metallic lines appear, intermediate spectrum, yellow-white light. In this group our own sun probably belongs with Capella, Arcturus, etc.

(3) The least hot: carbon appears in spectra with its flutings; many chemical elements and even chemical compounds, shades of red.

In this tabular statement there is indicated an evolution of the various chemical elements from one or two which exist only in the hottest stars. Hydrogen would seem to be the primary element, the lightest of them all. The low heat of the red stars permits or perchance aids the formation of chemical compounds, and thus begins to foreshadow our terrestrial substances. All this is de-

clared to indicate a cooling down of the stars, and a slow decline of stellar life. The result is, from this point of view, that the physical universe appears to be doomed to extinction. The original endowment of heat or energy is being dissipated, gradually squandered through space, like our sunlight. The star-life, which is the sun-life, is ebbing, and with it must go all other life.

Noteworthy is the fact that the foregoing three stages or types are gradations of a decline in temperature, and hence show a movement toward cessation of stellar heat and light. The result is that recent science at this point strikes a melancholy note of the final evanishment not only of life, but of the sun and even of the stars. But is there no return out of this dark negative phase of the Cosmos? The first type represents the hottest stars, the maximum of heat; then how did this get to be? The stellar evolution must be upward to the maximum as well as downward to darkness and coolness. The nebula may develop into a sun and its system, but such a sun has not yet attained its culmination; it is not yet at its hottest. The possibility is therefore suggested that the rise must be directly connected with the fall; and that the fall must somehow be brought around through darkness and linked into the rise.

There is a distinguished scientist who drops the elegiac strain of universal dissolution, and gives relief by showing an evolutionary circle of stellar

development. On the whole astronomers are inclined to question his view, and undoubtedly it is weak in proof at various points. Still as a theoretical forecast of what is coming, it seems to us very significant, indeed prophetic.

The allusion is to the conception of this subject unfolded in Sir Norman Lockyer's work on *The Meteoritic Hypothesis.* Such a table, however, hardly gives the full sweep of its thought which deals with the whole cycle of stellar evolution—from cold to hot, from hot to cold, and back again to the start. We may divide this cycle into three segments at least (possibly a fourth might be inserted). Lockyer's chief distinction between stars pertains to those of a rising and those of a falling temperature. Through his spectroscope he formed a considerable number of groups of stars which showed an equal temperature, having the same elements and the same length of spectrum. But in a stellar group of the same temperature he observed a new difference: some had thick hydrogen lines and thin metallic lines, others quite the reverse. Now comes Lockyer's pivotal inference: the thicker hydrogen lines with the thinner metallic lines indicate a body getting cooler, while the reverse indicate the body getting hotter. With this test Lockyer constructs a table of stars of increasing and decreasing temperatures. Moreover, he gives no less than ten different grades of each kind of stars. According to him the hottest stars

are two in the constellation Argo; the least hot are two in Pisces, almost ready to lapse into darkness; between these extremes are eight other gradations of descent, two of which are represented by the very brilliant stars, Sirius and Arcturus. The coolest rising star is Antares, followed by eight others in an ascending line (among them the prominent stars Aldebaran, Polaris, and Rigel,) up to the apex of the two hottest stars in Argo. So much for Lockyer's double table of rise and fall.

But this is not the end. The star passing into darkness and coldness becomes a meteorite, and possibly through explosion or collision, or both, is broken up into many meteorites of which the cosmical spaces are full. By means of attraction they gather in vast swarms, and through mutual friction they begin to generate heat and then light. The nebula, advancing again to starhood, is composed of this original meteoric stuff, which continues to rise in heat and luminosity through its own inner bombardment of particles. Somehow in this manner a dead star passes through its grave and enters upon its resurrection. There is no doubt that here the proof is notable for its absence. We find no tell-tale light, not even that of a hazy nebula, to whisper even the existence of such an underworld. It would seem that the star, after a bright, radiant existence in the Heavens above, must pass through a dark Purgatorial journey to its regeneration. So there is a stellar palingenesis as well as a human.

Such is the third segment, the invisible one, of the total evolutionary cycle of the star, the other two segments being visible. In a general way we have to construe from their arcs the complete circle, though the line certainly runs in the dark. This segment begins with the star vanishing, taking a plunge into night, and then emerges with first faint dawn of nebulous twilight, like that seen seen in many nebulæ. From that point we have observed the celestial fire-mist evolving into a star which rises to its maximum of heat and then begins to drop toward evanishment.

It must be repeated that all this is but a theoretical outlook over a field concerning which science is still to furnish its proof. So much, however, can be pre-affirmed: the burnt-out suns of the Cosmos, like the corresponding human corpse, is in some way reduced to its original elements, not merely to cosmic dust, but doubtless to the primordial ether, of which it must be re-made, and with which it must begin over again. All the stars having run their course of illumination, are to be sent back to their first fountain of existence, taking a fresh dip in their original protoplasm of Matter itself, during a sleep in the millennial night of their cycle. A similar round man goes through every twenty-four hours, the earth every year; nations also, rising and falling, seem to require such a regenerative baptism after a period of a few centuries; the sun himself must take such a dip, say once in

a million of centuries, though time in such a case cannot be counted or conceived.

Such, then, are the three segments of what has been called the cycle of the stellar evolution. One of them embraces a world-subsidence moving toward a world-emergence, through a sunless passage. We behold a rise, a fall, a return to the beginning—a construction, a destruction, a re-construction. We may well think that this world-evolving round of the universe is the colossal outer image of the inner process of the Pampsychosis, more nearly its visible external counterpart than any other shape of Nature, being quite all-embracing.

VII. There is thus brought before us the conception that each individual star (including our own sun) is passing through a cycle of existence which has its analogy to a human life. The star as individual is born, rises to its greatest intensity, which is manifested chiefly by its Heat, and also its Light, then gradually declines toward extinction, which is marked by what has been termed its Heat-death (Wärmetod). This is practically its dissolution into its original particles or atoms, which in one way or other are sent flying through the celestial spaces till the reconstitution of a totally new individual star begins. Such is supposed to be the round of the star-stuff in the physical universe.

The next thought is that the many millions of

stellar individuals which we behold in the sky, are just now in some stage of this round more or less advanced. A chief object of astronomical science is getting to be the discovery and description oi the present stage of each particular star, beginning with the most important ones. We must here on earth find out what the stars are doing, with the assurance that they are engaged in some important work of the universe. They are associated in some great end, each is performing its part in the vast social totality of the Pancosmos; what this part is must yet be precisely determined. It seems to be generally conceded that one of their functions is the making of the chemical elements; hydrogen or proto-hydrogen appears in the hottest stars, later comes our life-giving oxygen, and finally carbon. It would seem as if in this stellar evolution the conditions of life, as we know it terrestrially, were in the process of elaboration. Mr. Lockyer makes much of the fact that sodium is found in the hottest stars and also in our sea water, whose salt contains so much sodium. Animal life is supposed to have started in the sea. Man still uses salt in his food, employing apparently an element which was elaborated for him millions of years ago when our sun was at its hottest and before the earth was detached from the Heliosphere. Vegetables feed on liquids and gases whose elements had to be generated in the grand cosmical laboratory which we have seen at work.

Animals take chiefly vegetables and other animals for sustenance, yet they too require the gas and the liquid. The elemental conditions of life seem to go back to a stellar evolution.

The tendency is at present to reduce all chemical elements to one original matter out of which they arose. All the elemental diversity which we behold is thus unified. Chemistry did a great work in decomposing the myriads of our terrestrial compounds into the seventy or eighty elements which it declared to be ultimate and indecomposable. But now spectroscopic analysis of the stars is affirming that these elements are themselves compounds which are found decompounded in the enormous heat of the stellar laboratory. For instance the assertion is made that "iron is a compound into the ultimate formation of which hydrogen may enter" or other gases (Lockyer, *Inorganic Evolution*, p. 82).

The position of Heat in this far-reaching cosmical development is very striking. It is taken to be the unifier or simplifier of all elemental difference. Our chemical appliances can produce no such Heat as that of the hottest stars. The most powerful battery gives a spark barely equal in intensity to the coolest star (that in Pisces). Our sun is hotter (say 8,000 degrees Centigrade), but the most intensely heated stars, those in Argo, are supposed to reach 20,000 degrees and even 30,000. Of course these figures are conjectural and are simply in-

tended to hint the gradations of stellar development. Heat seems intimately connected with the earliest form of hydrogen, which itself may be a compound of some more primordial element, as certain physicists have suggested. It is a curious fact of the history of chemistry that Prout, in 1815, long before the discovery of spectral analysis, held that hydrogen was really the first element on account of its slight atomic weight, and that the other heavier elements were made or evolved (we may say) out of it. Of course Prout could not prove his view by direct experiment, and so it lapsed for more than half a century, till recently the stars in their courses appear to be coming to its proof. As Heat is the great agent of expansion, it is best manifested by hydrogen, the most expansible of all the elements; the two may be thought therein to have a certain primal kinship, hydrogen being nearest and most responsive to Heat. In fact the surmise has dawned that Heat itself may be the primal element which differentiates itself into all the rest, being a mode of Motion (as the statement runs) and consequently a mode of Matter, since Matter also is now getting to be considered a form or mode of Motion by some physicists. Thus we are being carried up by the new science to the first elements with which the Cosmos starts —Motion and Matter. At present, however, the earliest manifested or realized elementalization of the universe would seem to be this proto-hydro-

gen which is apparently produced by Heat out of the nebulous fire-mist.

In such fashion we behold the struggle of science to reach back to the very forge of the particularized Cosmos in all its material diversity. How did this vast multiplicity of bodies and their constituent elements arise? Heat is the cosmical power of unifying such diversity, and of reducing it back to its one elemental origin, whatever that may be. The earth with all its variety, and the sun and all the planets are now marching toward their starry fire-bath, into which they have to be dipped periodically for regeneration, say once in a thousand million of years. Then are supposed to be begotten a new sun and a new earth, which, however, again enter the round. Heat we may call the dialectic of the diversified, particularized universe of Matter, which through its own collisions generates the Heat undoing it. The nebulous fire-mist is supposed to be a mutual bombardment of particles till they become self-luminous, and finally glow in a stellar furnace which fuses them with a Heat far greater than that of our sun. Thence they are moulded or transformed in some unknown way, and cool down into an ever-increasing diversity.

One of the stages which this descent of cosmical Heat reaches is that of terrestrial life. It is an astonishing fact that animal and vegetable vitality is confined to so few degrees of the thermal

scale of the Cosmos; relatively it seems to be hardly more than a point at which organic evolution interlinks with inorganic. No life, as we know it, is there in stellar or solar development, and it is contained merely in a fraction of the earth's history. Man has arisen and existed only in a fraction of this fraction; he lives in a limited measure of Heat, of which too much or too little is equally fatal. Is the end of this colossal inorganic evolution to produce a living organism on a planet? This is a question that properly comes up in the treatment of the Order of Life, or the Biocosmos, which is the third main stage of total Nature in the present work (see preceding p. 21).

From time immemorial the sudden appearance of a new star has caused speculation as to its origin. The most probable ground for such a phenomenon is some kind of collision. Lockyer thinks that it comes from the clash between a nebula and a meteoric stream. Such a case might be regarded as the birth of a star, which thus begins its period of brightness, and starts in its cycle of rise, culmination, decline, and death. Here, however, enters another problem: the sudden disappearance of certain stars. In fact both the sudden appearance and the equally sudden disappearance of a star have been strangely united in a phenomenon which took place some years ago (February, 1901). This star is known as Nova Persei, which blazed up unexpectedly and in a

few days attained the brightness of Capella; then it began to wane, and with little fluctuations of luminosity dwindled to a barely visible point of light. This cycle of birth, culmination, and decline was passed through not in a milliard of years but in a few weeks. The conflagration of æons seems to have occurred all at once from causes unknown. If our sun had taken fire and burnt up in a month at its start instead of doling out its heat as it has done and is still doing, it might have furnished a parallel to Nova Persei, and startled the wondering denizens of some distant planet. Of course we terrestrials would never have been as we are; possibly all of our constituent elements might have gone into some other solar system.

Temporary stars have been often observed in the past, and it is highly probable that they in some way belong to the total stellar system. Besides the theory of collision already given, some scientists hold to the theory of internal explosion —the corpse seemingly being blown asunder by its own gases and set on fire by its own friction. The variable star appears different, though also a marvel of the skies. The best known is Mira Ceti, which rises at times to the second magnitude, then declines to invisibility for five months, after which it gradually emerges to its supreme brilliancy. Its total round takes up not quite one of our years—331 days. Another famous periodic

star is Algol (Beta Persei) which in less than three days runs through its cycle of variation, which is not fully two magnitudes. These are very rapid changes, but there can be little doubt that all stars are undergoing similar changes, which are probably phases of internal evolution. The comparison is usually made with our sun, which has its periodic return of solar spots every eleven years. There is also a problem of varying scintillation of the stars, which has attracted the attention of astronomers.

It may be reasonably affirmed that all the stars of the firmament are going through their cycle of individual change, lasting from a few hours (like Algol) to hundreds or thousands of years. They are all evolving, we may say, and the further noteworthy fact is that they evolve cyclically, ever returning upon themselves in order to go forward. The Cosmos seems to take a strange delight in rounding both the Matter and Motion of the celestial order; the stars change internally in cycles as far as we can discern their behavior; their external movement, both axial and orbital, runs into circularity. It is conjectured that the First Motion, parent of all others, must have been circular. Still further, this cosmical character is consonant with the Self, universal and individual, which moves and evolves quite in the same way, and ultimately must have come from the same creative source. So we behold the one psychical

process pervading and ordering the universe, both inner and outer.

VIII. We must now bring to a close this somewhat discursive introduction, necessary on account of the present state of the science (as it seems to us) whose general trend and character we have sought to indicate under the title of the Systemic Cosmos. But the distinctive word here employed demands the system; astronomy also calls for the law of the stellar world. A sense of order is everywhere felt in the Cosmos and drives to some organic expression of its phenomena, though this be but tentative.

In what way can we put together the total Systemic Cosmos as we have seen it unfolding? Evidently it embraces much diversity, and seems on the surface to be recalcitrant to any order. The so-called new astronomy with its dominant physical turn appears in a somewhat reactionary mood against the previous mathematical astronomy, which was itself the child of an even greater reaction.

There are certain general outlooks which we may take in advance upon this subject. First of all we must sooner or later seek to bring the physical universe as a whole under our ken and try to find some lines of order running through it in its entirety. But this whole must be divided, particularized, made visible in all its separation—which fact we behold in the stars of the cosmical

totality. But we are not to be left in such a stellar distraction; the single star is to have its own order or system, which in its way reflects and indeed realizes the whole Cosmos in which and by which the star was evolved.

Putting these items down in a more formal statement, we have (I) The Systemic Cosmos in its immediate totality, which we shall name specially *the Pancosmos;* (II) The Systemic Cosmos in its visible, truly luminous, yea self-luminous separation—*the Stars;* (III) The Systemic Cosmos in its organized individual, which is the basic unit of it as system, and from which it has to start in order to make the Whole (or the Pancosmos) into a system—*the Sun.* Thus we may behold the last stage returning to the first through the second—each star being supposedly a sun with its system.

The human mind cannot and must not repose in a scattered presentation of facts; it should and will seek ultimately its own deepest process in Nature, which in that way only can become transparent to thought and so a science. Still it is not said that the above process as formulated is final and cannot be improved; subject to evolution is this ordering of facts, as is everything else.

I.

The Pancosmos.

In the Systemic Cosmos we are forced to reach back to its beginning, which is the cosmical All,

or what we have here sought to emphasize by naming it the Pancosmos. We must in some way grasp the whole at the start and see it evolving its various stages. To be sure we may go the other way, commencing with the part and rising to the totality. Already the attempt has been made to bring into the conception of the reader the grand spheres of the physical universe—the Heliosphere, the Galactosphere, and the Cosmosphere—though this last one be as yet barely suggested in the far-off nebulous masses revealed by the largest telescopes. At present, however, the process is different; we wish to see as far as possible the evolution of the Whole as cosmical, and this must be our starting-point.

The Pancosmos is, accordingly, the physical universe taken as immediate, undifferenced, as yet undeveloped. Still in this stage we must suppose that everything which is to come hereafter is seething; not only gravitation is present, but light has faintly dawned and shows itself in the filmy nebula. Very impalpable is such a theme, but we must note a few organic points, which in a sense are later developments. At present some universal lines of order we would fain trace in this vague and far-off world, yet very real.

I. Postulated. If we start with the Pancosmos in itself, or empty, we must at once put something into it; we must determine the undetermined universe. We have previously found Motion, for

instance, to be an universal element, or an element of the universe as physical. Here we return to it and pick it up simply as a postulate without further derivation. These postulates are, therefore, immediate or so employed for the purpose of giving content to our primal conception of the Pancosmos.

1. *The Elements.* The word here is intended to bring back the primal forms of the elemental Cosmos which have been already set forth quite fully—Motion, Matter, Measure. These we merely recall at present, since there has been a return to the beginning of Nature. The Systemic Cosmos is peculiarly the arena of all these in their largest manifestation; they are no longer abstract or ideal simply, nor are they confined to one small planet (as in the Particularized Cosmos); the moving Body is now to be measured in all its grandeur. Motion is indeed incorporate, but as a kind of soul controlling the material spheres. The Pancosmos is thus full of Motion, full of Matter, all measured and in order, which Mathematics is to re-measure and to formulate in its own terms.

2. *The Radiants.* When we behold a nebulous shred in the most remote skies, it is emitting light, which has evidently come to our eye across the enormous spatial chasm. Such is the visible Radiant, and with its generation is connected doubtless heat, and probably electrical action. These three Radiants—Light, Heat, and Electricity—be-

long to the Diacosmos in their special treatment; but here we have to consider Light as that which manifests the Pancosmos, or at least certain fragments of it. For the unseen probably remains more than the seen in spite of the ever-increasing conquests of powerful telescopes. This radiating Light which is borne to us so far, has to traverse or to stir sympathetically some kind of a medium, which must be everywhere, invisible indeed, but the bearer of all visibility.

3. *The Medium.* Is the Pancosmos completely realized? or we may say materialized? The question asks after a common medium, which in a way can be supposed to fill the spatial emptiness of the physical universe. Science is inclined to accept a universal presence of matter of extreme tenuity throughout what we here call the Pancosmos. If Matter be the separated, this ether is the first form of it, perchance the protoplasmic stuff out of which all diversity of bodies proceeds. Ether would seem to be in itself a kind of repulsion, as the first Matter or the Separated; but on the other hand it must also be the conveyer of attraction throughout the Pancosmos. In the mechanical view of the world gravitation is supposed to work upon the total ether and thus to reach every piece of Matter in the universe.

These three things or sets of things are what we postulate for the Pancosmos, in which they have been put, after being picked up from the

outside, for the purpose of filling the empty All, or of defining the indefinite Whole. Postulated are the Elements (already given), the Radiants (hereafter to be given), and the Ether, which will likewise have a history. Having gotten some tools (or categories) with which to work, we may take the next step which is to determine the Pancosmos not from the outside, but from the inside, if this be possible.

II. Sphered. The attentive reader must have already noticed our tendency to sphere the universe, to divide it internally into a succession of spheres, from least to largest. Such a tendency can be found in many astronomical works, even if unconscious; indeed it lies in the very nature of the subject. We may conceive the Pancosmos dividing itself primordially into the three spheres—those of the Sun, of the Galaxy, and of the Cosmos—and thus revealing the first phase of its system.

If we look up at night we seem to be living in a sphere whose radius is not known, though we take ourselves to be the center; or perchance the earth on which we stand we conceive as central. Thus naively do we sphere our little world, showing an inborn conformity of mind with the outer universe. Still this primal geocentric act of ours has to be given up, and we have to place ourselves in conception upon the sun, thus becoming heliocentric, and thinking or rather re-thinking and re-creating

by thought the Heliosphere in its organization and evolution. Then we behold a vast multiplicity of Heliospheres in the stars, which also show to the eye a bent toward a common sphericity in the Galaxy or Galactosphere. But this too seems to be revealing a multitude of forms through the investigation of the nebula, and is evoking a new sphere, all-embracing yet spatially limited, the Cosmosphere, which as yet lies beyond immediate vision. Indeed the beginning, the Heliosphere, is not directly visible even if we see the sun. We have to construct it, or rather reconstruct it in our own mental might, re-thinking the divinely creative thought of it, putting ourselves upon the standpoint of the Creator, or we may say, of the Pampsychosis.

In the evolution of the nebula we have seen its outcome in a Solar System like ours. Now there are many such Solar Systems scattered through the Heavens; in fact every star is supposed to be the luminous center of a planetary order. But we observe that the stars are gathered into groups or constellations which, however, do not indicate any inner connection. A star in the Pleiades is possibly as far removed from one of the same group as is our sun, which may appear from the other side to some distant inhabitant of a planet as one of the Pleiades. Still there is a single vast gathering of the stars in the firmament which impresses the mind as possessing a common char-

acter, as having some internal bond of relationship. This is the striking stellar zône of the skies known as the Galaxy or Milky Way, of which our sun is a tiny star, and our system a minute part. Thus the latter belongs to a far larger celestial order, which is still visible, though bordering outwards upon the invisible.

It will help our conception of this mind-stretching theme to put together in gradation the three stages of the present world-system, as they have been already hinted. We must recollect that the nebula has unfolded into this explicit cosmical system, which, however, shows these various forms when developed, differing especially in magnitude. As they all are probably round or tend that way, and are also rotating, we shall designate them as spheres.

1. *The Heliosphere* may be conceived to be any stage of a solar totality from its primal nebulous condition to its fully developed system. As man dwells at present in a certain epoch of a given Heliosphere, it is that part of the total Cosmos which he can best study and understand. It is indeed the systemic type of the cosmical universe, through which chiefly we have to reach out to the remotest stars. There is little doubt that the Heliosphere in its primordial evolution as nebula breaks away from a larger mass of which an example may possibly be seen in that vast Nebula of Canes Venatici. This seems in its present

state to be whirling off Heliospheres, which will in time evolve Solar Systems like our own.

2. *The Galactosphere* we may call analogously the round of the Galaxy or Milky Way, which is the stellar girdle making the circuit of the whole sky, though we see only the half of it above the horizon. In this girdle the stars are largely gathered, in striking contrast with the celestial regions lying outside of it. Often it appears to contain nebulæ, but these are usually resolvable into individual luminous points by a good telescope. The true nebulæ mostly lie outside of the Galactic belt—a fact which may imply two different stages of cosmical evolution in two different portions of the Heavens. The Galactosphere holds chiefly the developed systems with their suns, each of which announces itself by its light. Our own sun with its system is a member of the untold myriads of the Galactosphere whose stars revealed by the best instruments have been computed at a hundred millions. Sir William Herschel once counted in a small area of it covered by his telescope 331,000 stars.

Strictly the Galactosphere must have its poles (known as the Galactic poles). The Galaxy proper is its equatorial belt, upon which so many constellations appear massed in a vast celestial circle. What has brought them together? We naturally think of motion, indeed a whirling motion, which like that of the earth draws its material toward

the equator away from the poles. This seems to have been what suggested Herschel's famous comparison of the Milky Way to a grindstone, whose diameter according to him is about five times its width. Such a view has its difficulties unquestionably, but the general conception of the Galactosphere as a kind of system of multitudinous solar systems, doubtless millions of them, cannot be dispensed with in co-ordinating the Systemic Cosmos.

3. To the idea of *the Cosmosphere*, though very faint and indefinite, we have to advance out of the Galactosphere, whose general lines are in a measure visible. Still they run out beyond and beyond till we begin to think of a multiplicity of not merely Solar but of Galactic systems. Already the large nebulæ have suggested that in them was forming something far greater than the greatest Heliosphere, perchance a new Galactosphere. The recent revelation of starry depths has compelled the thought of not only other suns but of other Galaxies. Average eyesight can see six stars in the group of the Pleiads; better vision can detect the seventh, and still better the eighth; the supreme ocular test is said to be a glimpse of the thirteenth Pleiad. No wonder there is the legend of the lost Pleiad; several are lost or found according to the seer. But the best vision is that of the photographic plate which brings out more than 2,000 members of this group, according to a picture of it taken at the

Paris Observatory. Such a fact suggests another group of Pleiads far beyond our visible group, in another Galactosphere, or perchance many such groups, each in its own Galactic system.

So we cannot permanently halt in our Galactosphere with its millions of Heliospheres, and among them our own; we have to attain the one Cosmosphere embracing all the possible Galactospheres with their Heliospheres. To such a conception of the physical universe (or the Pancosmos) we have to reach out, however vast and elusive. But the question rises, Is it, too, in motion, revolving likewise on its axis? And is that the original universal Motion of the Universe itself, creative of all other forms of Motion, rectilineal as well as curvilineal? We have to conceive, then, the Primal Motion to be spherical; yea cosmospherical, that of the physical All itself. From this universe of Motion (really the moving Universe) all finite particular movements are thrown off, or we may say generated. The autumn leaf whirling from a tree participates in the all-moving All of which it is a fleeting manifestation. In the fall of the apple Newton saw the universal gravitation of Matter to Matter, but did he also see universal Motion? To him seemingly Matter, being impelled by the force of attraction, picks up its needful Motion, as it were from the outside; but we have to ask, Whence comes this Motion which appears to be lying around everywhere through the celestial

spaces? Or we may put the question in this way: Which is prior, Matter or Motion? The answer carries us back again to the starting-point of the elemental Cosmos, where we saw Motion the first-born of Nature.

But if the total physical Universe turns on itself (as the word *Universe* might seem to imply) it must be finite as distinct from the All-Ego, though taken in itself as spatial it is boundless. The Cosmosphere as derived is, accordingly, limited against its source, the universal Self whence it sprang and separated, receiving therefrom its separative character. Hence comes that deep pervasive contradiction of Nature which we have already noted and called its dialectic. This is indicated in the statement that it is in one way boundless, in the other way bounded—spatially infinite, genetically finite. The Cosmosphere is conceived to be in the spatial Pancosmos which is still beyond it, and hence brings up again the dualism inherent in the physical universe, that between the finite and infinite, between the sphered and the unsphered, between the self-returning and the onward-going —the dualism which we have already come upon and observed under a variety of forms. Nature is twofold and cannot help herself; she has the return, the rotation, which is limited, yet is always sweeping out of it into the unlimited.

Now this break-up of the ever-repeating round means evolution, means the creation of new forms.

Each part evolves of itself, or we may say it revolves in its own right like the body from which it sprang. This fact we shall look at once more in its present connection.

III. Evolved. We have already given (see pp. 251–61) a general outline of the evolution of the stellar and planetary worlds, as it has been presented in recent science. At this point we may again call up briefly the aforesaid evolution, putting it into its place in the Pancosmos, which is now to be seen in its unfolding. The three spheres just described in their separation have to evolve; indeed we may add that they have to revolve, in order to evolve; the cycle revolving at a certain speed leaps out of its own skin as it were, and becomes another which also revolves. We may summarize the essentials previously given:

1. *The first nebula.* As the visible starting point may be taken an exceedingly tenuous, but self-luminous piece of matter which doubtless rotates and flattens gradually through its rotation. There are evidently various subordinate phases of this first stage of a nebula, but the many thousands of nebulous masses (probably extending to millions) have yet to be organized. Still we may note the second pivotal fact concerning them.

2. *The Spiral.* Nebulæ in the course of their development, range around a center like the whorls of an ammonite, with lines of cleavage across these whorls, indicating the future planets and perchance

satellites. The center is the mass of the coming sun, though this too may break in twain. There is little doubt that the rotation also divides; the inner whorl gets to moving faster than the outer, which motion precipitates the break, and throws off the first planet of the system, to be followed by others. This stage is one of great agitation and division; the spiral is what tears the nebula to pieces, scattering its parts at a distance from the main center, yet holding them still in the bounds of a system by gravitation.

3. *The System.* This reveals, accordingly, a unity in spite of, or rather through, its separated bodies, each of which revolves about a central sun, and at the same time turns on its own axis. We have already seen how a ball thrown off from a whirling sling has a spinning movement as it flies through the air. When the planet is separating from the spiral, the outer side as farthest from the center must be going faster than the inner; hence it will tumble over and around itself when free. Its axial motion is, therefore, an indication and a consequence of its liberation, showing its new distinct individuality, which of course, it could not possess while held fast to the original body.

So the system unfolds out of the nebulous spiral which shows a genetic energy in producing separate cosmical individuals. Yet their original rotatory motion around the center is preserved, but it now becomes axial. That is, it has been appropriated

and internalized by the new-born planet or the moon, which in this way has received from the whole (as revolving nebula) its characteristic motion, namely its revolution on its axis. We see that in this most external manifestation of Nature the part of the given totality must have the process of that totality in order to be such a part. The thin nebula, the slightest visible matter that moves, gives its own essential motion (the rotatory) to the particle which separates from it, endowing the same with its fundamental rotation. So the original spiral begets children—suns, planets and satellites—all of them individualized with its primeval motion, which becomes theirs through a sort of parental impartation. At this view we penetrate to the basic principle of cosmical organization, to the primordial visible union of Motion and Matter, the first-born of the Cosmos, with which we started. In other words, the germinal process of the total Cosmos has now unfolded and become explicit in a system, and hence we call it the Systemic Cosmos or the Cosmos systemized, which has gone back and shown us the ideal elemental Cosmos realized in the primal moving Matter, and therein appearing for the first time to the senses of man.

Now this systemic motion of worlds, starting doubtless with the first physical All, and extending to the separate individualized parts of the same as systems, has its deep correspondence to the inner world, that of the Ego. This also shows each part,

or better, each activity of itself to be endowed with its own total process. The separate faculty (as it is often called) has the same essential motion which characterizes the entire Ego. Each has the psychical movement as its essence, which we have named the Psychosis, and which is the connecting link of all particulars with all universals, or the very process of the universe revealing itself in each part of itself. We have often heard of the Microcosm, or the little inner world of the self and its correspondance to the Macrocosm, or the great outer world, the physical totality. The node in which the twain are conjoined through and through with all their divisions, is that psychical process, the Psychosis, whose reality in the vast spatial externality of Nature, is the Systemic Cosmos.

We may repeat, for the fact is pivotal, that the primal generative nebula is the potential undifferentiated mass of revolving Matter, big with worlds; then comes its stage of parturition, or its separation, not only into Bodies but also into Motions, the axial and the orbital—this being the very act of the birth of worlds; finally these generated Bodies in their own individual revolution also revolve about their central Body (the Sun) which has its own axial revolution, and likewise an orbital movement which connects it with another far greater system, indeed connects it with all cosmical systems, or with just the cosmical system of the All.

If we look back at what we here have named the Pancosmos, we observe that the physical universe is grasped in its most immediate phase, as it is in idea before it has fully unfolded into reality, though in the nebula it be on the way. But now we are to be introduced into the presence of the Pancosmos particularized, shaped out of its ideal or nebulous universality into single limited forms, which manifest themselves in their own sheen. The stars now rise on this book and (we hope) on our reader's mind.

II.

The Stars.

It is something of a problem to find the basic division of the Pancosmos, inasmuch as it can be split up in many ways. But the most striking example of the separation of the physical universe we behold when we look at the Heavens in the night. The All of Nature is there cut to pieces, scattered through the spaces and is illuminating its own vast primal diversity. Day is a kind of unifier with its common light; the sun conjoins and as it were associates the multiplicity of things seen, wiping out for a time the separated stellar worlds above. Night on the contrary may be called the separator, darkness gives the foreground and also the background of the grand astral manifestation of the Cosmos. Starlight may be taken as the opposite, separative counterpart to the unity of sunlight.

Blank space shoots into its points which become self-luminous, and draw on the skies many geometric figures. From time immemorial the stars have suggested geometry which is properly the first mathematical science. Imagination has filled these skeleton lines with human forms and thus produced the constellations; the plastic sense of the Greeks saw in them the departed Gods and Heroes who were thus translated into their new home higher than Olympus where they are still found in name.

We may see, therefore, the Pancosmos particularizing itself in the stars millionfold, which are thus its first true reality. It now becomes visible, being hitherto rather a thought or idea, though absolutely necessary. This is, accordingly, a significant step in the total cosmical system, that of astrogenesis. We have already considered stellar evolution, as it has passed through the various stages of the nebula. And yet that very first original nebula out of which the primordial star was evolved—whence? We have to go back and conceive the creative act producing Matter or Nature, even if we cannot verify it directly by experiment. That may be outside the realm of Natural Science, but it is not outside the realm of universal Science. We have also considered the cycle of the star as unfolded by Lockyer and others—its rise, bloom, decay and death, till its regeneration. But this seems a closed cycle, which had somehow to become—how, whence did it start? The question

again throws us back to the creative idea which underlies the whole physical universe as derived. But we need not repeat here our view of its origin and evolution from what we call the Pampsychosis. Nature, when interrogated persistently and profoundly, will always whisper to us that she is not finally self-organized, and will conduct us back to her source. She is but a stage, a part of the total process of the All-Self, to which she will always in her last text refer the desperate seeker.

The stars, then, we contemplate as the mighty visible manifestation of separated Nature, which is itself the primordial separation of the Universe as a whole. Such is the emotion which they excite, for they necessarily carry the human spirit to the unseparated antecedent stage out of which they sprang. What produces such separation? We can apply our usual categories—cause, force, energy, law; but all of these likewise point back to something more fundamental, to that Totality which separates itself and therein is and remains itself. A natural symbolism the stars have always called up even in the savage mind, suggesting the unseen by the seen, and weaving a bright strand of poetry through the folk-lore of peoples.

The stellar world, accordingly, we conceive as the primal separation of the Pancosmos into its ultimate visible units, even if these may be still further separated and analyzed by means of instruments. We might say that the universe is

primarily atomized in the stars, between which lies the unstarred void. Or taking Space as the first cosmical element, we see the stars as points in it, yet belonging to it; we see Space again becoming punctate and showing it at the same time. In this view the starry depths are the great spatial manifestation; ideal Space they make real both as extension to the infinitely large and intension to the infinitely small. Moreover, the stars all differ among themselves, each has not only its own locality, but its own individuality. They are diverse in size, which fact the astronomers have signified in the stellar magnitudes. Astral colors have shown great variety and beauty, but they have also become significant of stages of cosmical evolution (see preceding p. 275).

In this brief survey of the stars, we shall consider, first, their Distribution, or their external order in the skies; secondly, their Diversity, or their outer and inner differences from one another; thirdly, their Measurements, or the attempts to find their distances and sizes.

I. Stellar Distribution. The very unequal distribution of the stars over the Heavens has always provoked some attempt to find the order or ground of such distribution. Some regions are quite starless, other localities seem afflicted with a starry plethora. What shall we say to such a conglomeration as that seen in Hercules (13 Messier)? It can hardly be called a cluster,

but a pile of stars somehow heaped up there in space. On the other hand there are portions of the sky, particularly outside of the Milky Way, which are star-poor. Is there any principle to be found in this very unequal stellar distribution? Usually some form of rotation is what causes a flight and a gathering of the particles of the body rotated. Is there any such vast rotation in the Heavens, for instance that of the Galactosphere? If there is, it remains a future task of astronomy to identify it and to trace its effects.

1. *Rich and Poor Regions.* In general we may, from the present point of view, take as the first distinction of the celestial vault that into star-rich and star-poor. Of course there is an unsettled problem here also: are there still millions of stars which are now invisible, but which are to become visible through new appliances or more powerful telescopes? It is estimated that the naked eye, if possessed of unusually excellent vision, can see 8000 stars; ordinary sight, however, can discern about 6000. A good opera-glass will double the number, from which there is an ascending increase till the very best telescope is said to possess the power of revealing one hundred millions of stars which embrace sixteen stellar magnitudes. That is, for one star seen by common eyesight, there are more than sixteen thousand unseen, but discernibie through a lens. Still further the sensitive photographic plate catches and holds fast starry light-

points which the eye is unable to receive directly through the telescope.

The above estimates relate to the total Heaven, of which hardly a half is visible at one time from any point on the earth. So an average pair of eyes will behold on a clear night three to four thousand stars. They are not therefore, innumerable; you may easily know more people in your town than you can see stars in the sky above. The old shepherds, watching in the night, easily made the acquaintance of all these starry denizens, and began astronomy.

There has been much speculation concerning the present stellar arrangement which we witness above us in the Heavens. What is the principle of the construction of the visible universe with its peculiar distribution of the stars? It probably turns on some primordial motion not yet detected in the very short time during which it has been scientifically observed. And this motion may be determined from sources not as yet visible.

2. *Seen and Unseen.* Very deep is the division between the Void and the Full; even deeper and more important is the division in the stellar world between its seen and unseen portions. We naturally consider a star or indeed any heavenly body as luminous; it has to appear before much can be said about it. Light is the herald of the skies, but this fair babbler may not always be present to speak through the heavenly spaces. Still a sudden

blaze may start in the far-off regions where previously was the unoccupied void as far as vision told us. What happened? Certainly an unseen body has become all at once visible, and we begin to reflect upon the lightless, seemingly defunct worlds which are floating everywhere through the Pancosmos. Moreover, the mind tries to fathom their purpose, their place in the cosmical order. Already we have given Mr. Lockyer's remarkable theory of the life, death, and resurrection of the star-worlds—the most satisfactory view yet promulgated in our opinion, even if not fully verified. Quite a number of new stars are recorded, as Nova Aurigæ, Nova Persei, etc. They are set down as twenty-five by Flammarion; other authorities say more, still others less.

The quantity of unlit matter in the universe cannot of course be told, but it is doubtless greater than what is lit and luminous. The unseen thus is declared to be more in amount than the seen. Certain perturbations have been supposed to come from the vast mass or perchance the dead carcass of a solar system or of an extinct Galaxy. Gravitation which works in the dark as well as in the light, may be yet made to tell the story of this non-luminous Cosmos. As our sun with its planets seems to be moving about some center which does not shine, the question rises, What is that center? If the whole Galactosphere has not only a rotary but also an orbital movement, we have to ask

after what compels it thus to gravitate. In the limits of our human experience and reason the mind has to posit a controlling mass seemingly not illuminated, from which springs the axial and the orbital revolutions of the Milky Way. In any case the unseen material bodies of the Pancosmos must be greater than the seen.

3. *Possibilities.* In this connection it may be permitted to mention that science has hardly been able to tackle the foregoing unseen portion of the physical universe, which appears to be of such enormous proportions and to possess so much secret power over the seen order. The chief means of communication, Light, being cut off, there remains that eyeless worker, Gravitation, whose effects we may well discern in a number of colossal phenomena. But there is a third medium, not yet fully caught and harnessed, whose possibilities do indeed seem the greatest. This is ether, as yet quite impalpable and invisible, which, however, is employed as a medium by Light, and possibly by Gravitation also. But the great coming scientific problem is to catch this ether in its own activity and to set it to work. Electricity would seem to have a certain elemental power over it, as we see in the phenomena of wireless telegraphy. Can this medium in itself ever be gotten hold of perchance by some mechanical contrivance, and tamed from its present wild state, in which it roams with freedom the cosmical spaces? If so, then we may be

able to find out somewhat about the other side, the unsunned and the unseen side of the Pancosmos.

Stellar Distribution, accordingly, runs against limits on all sides; the seen location of the stars puzzles us, but the greater part of them we cannot even locate in their unseen world. So we may study them individually a little, as they appear.

II. Stellar Diversity. The more the stars are studied, the more they are found to differ among themselves. Their separation is not merely external, they are not merely so many bits of bright matter strewn over the heavenly acres, like grains over a wheat field. To be sure, they all shine, but their sheen is of many kinds, their luminosity is diverse. It is obvious at the first glance that they are of different sizes, not so obvious is it that they have different qualities or individual traits.

Here is an enormous outlook upon the coming astronomy. Who can not only map and count the stars, and calculate their distances, but who can also portray their characters? The world-drama of Shakespeare with its Galaxy of humanity is indeed great; what then about a drama of worlds with its Galaxy of stellar characters acting on the stage of the sky, of which dramatic action we possibly catch a glimpse in that external galactic round yonder? All such knowledge is certainly far away in the future; at present we can only take note of a few outer differences.

1. *Magnitude.* Stars of sixteen different magnitudes we find set down in the books, also the photometric calculations upon which these magnitudes are based. The rule runs: if one star is two and a half times brighter than another, the first is a magnitude higher than the second. However, there is one supremely brightest star in the Heavens, Sirius, (the Dog Star), which is not only the first star of the first magnitude but equals in luminosity, six average stars of the first magnitude (such as Aldebaran). Next to Sirius is Canopus, which is followed by Alpha of the Centaur, our nearest star; Arcturus is fourth in the order. Nineteen stars are tabulated as belonging to the first magnitude in a decreasing line of brightness, all being different in this respect. At the sixth magnitude the star begins to vanish out of human vision and at the sixteenth magnitude it begins to vanish out of the present telescopic range.

The magnitudes of the stars are not absolute, but relative to us. A very large star will appear very small at a very great distance. Still the magnitudes have in them also the suggestion of size. Arcturus and Alpha of the Centaur are about of the same brightness, but the former is supposed to be eight times farther from the earth than the latter (204 billions of miles to 25 billions). According to the law of light we are forced to conclude that Arcturus in itself is a much larger star than Alpha of the Centaur.

2. *The Divided Star.* The striking fact of the inner separation of the star into two or more parts first became known through the telescope. But stellar division does not stop with one cut. There are triple and quadruple stars. The relation of these constituents to one another is by no means ascertained. Their motions become very complicated and indeed doubtful, the working of the law of gravitation is often quite inconceivable. The most seem to move in orbits, some of whose periods have been calculated, others are declared to sweep forward in right lines under unknown sidereal influences. Of these divided solar systems (for such they appear to be) double, triple, multiple, some 819 have been uncovered according to a recent count. That unique star Sirius is a double, of which one component is much smaller than the other and far less luminous, so that it was not discerned till 1862 (by Alvan Clark.) Indeed some suppose it to be a planet or satellite, but the difficulty is that it is self-luminous. Yet many doubles are quite equally divided as to mass and intensity of light, though the latter may be of different colors.

The double star must have its two parts related in motion. Not all stars which are seen in close proximity make necessarily a system together. In the true double star the counterparts usually revolve about each other; but sometimes they seem twinned in a common race for some unknown goal and move on a rectilineal path apparently. If the

doubleness be optical merely, the two stars have no systemic connection, and may be very far apart. Some astronomers make a great deal of the distinction between a double and a binary star, the latter being the true double. In this sense some stars are both binary and double, for instance Mizar in the tail of the Great Bear, which is both an optical double and a systemic double.

Of course our own star is single and very simple in its system comparatively; perchance when we understand it well, we shall be trained to grasp the far more complicated systems of doubles, trebles, quadruples, etc.

3. *Color.* There are 130 double suns of which each part has a separate tint; in most of them the contrast of color is pronounced. The light from two such luminaries would be perpetual (it has been supposed), there could be no night; or the difference between day and night would be a difference of colored sunshine; say half a day blue and half a day red.

The import of the different colors of stars has been set forth already in considering stellar evolution. It would seem that in the same double sun there may be a very old, dying part and a young growing part. Does this imply that the star, when it begins to be weak with age, can slough off its decrepit half for regeneration? There are bright stars which have totally dark counterparts. The periodic variability of certain stars is conjectured

to arise from a dead companion eclipsing them for a while.

Light alone announces the existence and the locality of the star, and possibly something of its size and stage of development. But color must reflect inner character. It might seem that the two fine arts, Sculpture (white) and Painting (tinted) have their correspondence in the stars. Says Flammarion: "In the Southern Cross we admire with unspeakable wonder a brilliant cluster of 110 stars of the 7th magnitude and fainter, of which the most luminous shine with all colors—ruby-red, emerald-green, sapphire-blue; it is like a casket of glittering gems."

So in this stellar diversity we consider first the magnitude or external size of the star, then its separation into two or more stars (or suns), then its color, which is some manifestation of its individuality or inner character. Of course stars have other points of diversity, but the foregoing seem the main ones, though science has barely begun the exploration of this remote field of research.

III. Stellar Measurement. The application of Mathematics to the stellar world is yet in its infancy. To early man came the question: What is the distance from me to yonder star? The quantitative instinct was active, but found no realization till recently. In 1840, as the record runs, the German astronomer Bessel first measured the distance to a star (61 Cygni). Other kinds of stellar

measurements are given in the books, such as the proper motions of the stars, the orbits of double stars, etc. Especially the motion of our own star, the sun, has been reduced to figures. A few items on this subject must suffice.

1. *Parallax.* The little child on the train saying that the cars made the trees run, gave an instance of one kind of parallax. Now the distance of a star is calculated by first ascertaining its parallax, which is in general the observer's displacement (real) projected into the displacement of the object observed (apparent). The radius of the earth's orbit is taken for the real displacement (93 millions of miles) or one side of the triangle whose apex is the star. This star has as its parallax the angle at which the radius of the earth's orbit is seen from the star. With these data the distance to the star can be readily measured.

The great difficulty lies in determining the parallactic angle. The distances of hardly more than twenty stars are accepted generally by astronomers. The curious fact is that some of the brightest stars have as yet no ascertainable parallax. To reach the nearest (Alpha Centauri) light would have to travel four and a third years, going at its rate of 186,400 miles a second. To reach Sirius it would require nearly nine years. It has been inferred that we are still seeing the light which comes from stars long extinct. And on the other hand some remote planet may be just now witnessing

the battle of Marathon. All this of course rests on the supposition that light moves everywhere at the same invariable speed with which it comes to us from the sun. That is, however, an assumption which can be questioned, and doubtless will be at some time questioned. Parallax depends primarily upon light. Still some of the brightest stars, like Canopus and Rigel, and others of the First Magnitude, show no perceptible parallax. On the other hand some quite small stars, like 1830 Groombridge, rather easily give up their parallactic secret. The magnitude of this star is set down at six and a half, thus it is quite invisible to average eyesight. Its parallax is about the least (0,045) and its distance is so great that it would take light seventy-two years and a half to cross over from it to us (according to Flammarion's table). This is also regarded as the swiftest star of the skies; possibly its enormous velocity has some connection with the preceding facts. More about this unique star under another head.

2. *The Unfixed Stars.* Through our own eyes as well as through all Literature (one thinks of Dante specially) we have seen the stars fastened in a sphere which revolves. The truth is, however, that the stars do move, each in its own peculiar way, which constitutes, we must think, a manifestation of character. They are thus individualized, having their own real motion, which is known as their proper motion in the books. The old con-

ception of fixed stars is no longer tenable. Each star possesses in its own right an individual movement, and its own rate of speed; the stellar world is a world of continuous change and variation among its individuals.

There is one set of stars which are moving toward us (our Solar System); another set of them are receding from us. Moreover, their rates of approach and recession have been measured. The bright Arcturus is reported as sweeping hitherward with a velocity of forty-one miles a second. The arch star Sirius is said to be fleeing from us at the rate of twenty-two miles a second. The supposed twins of the skies, Castor and Pollux, do not harmonize in their actions toward us; one is leaving, the other coming. Doubtless all stars are thus moving in relation to us, and also in relation to one another. We learn that Alpha Cygni is rushing in a straight line toward us at the rate of forty miles a second, and will reach us in about 200,000 years, bringing a new sun, which may take the place of our old one when it is extinct. Possibly this is the solution of the problem of our slowly expiring sunshine, which has been worrying scientists and others in recent years. Thus the sky seems cut up everywhere with stellar roads—leading whither?

3. *The Fixed.* The stars, instead of being fixed, are just the unfixed, the ever-changing manifestation of the Pancosmos. Out of such separation

the mind seeks to bring them into some sort of unity, preserving of course all their diversity of movements. In the preceding vast complex of the motions of a hundred million suns, is there any common motion? Are they as a whole circling about some center? Astronomers have generally held that there is such a center, though dissenting voices are heard. Among scientists is a notable effort toward finding this center of the sidereal system as a whole. To such precedence no star can lay claim; but some have imagined an enormous unseen central mass which exercises control over the totality through gravitation. But it is confessed that measurement has not yet been able to determine any such object, which remains a conjecture. Still a general movement of the stars all together has been designated.

Much more decisively is our sun with its planets asserted to be moving about a center, and its orbit in this vaster revolution has been calculated (see p. 270), though great doubt still hangs over the whole subject. The sun is going toward Vega of the Lyre, and Vega is also coming toward the sun; the two are said to be rushing together at the rate of forty-four miles a second. But each is probably moving in its own stellar orbit with its planetary retinue. To ascertain these stellar orbits, is reserved for the astronomy of the future.

The star whose proper motion has excited the greatest astonishment among astronomers is known

as 1830 Groombridge (number and name taken from a catalogue of stars). It is hardly visible to the naked eye, but its velocity has been measured and found to be greater than that of any other star, and quite out of proportion to the average stellar speed. It has been called the runaway star, and regarded as an alien to our whole sidereal system; some think that it never could have been evolved under our astral conditions. It has been supposed to be simply crossing our Galactosphere into another, perchance like a traveler in great haste trying to get back home. The idea at least suggests that we may have visitors in our worlds, who will some day be able to tell us of their most remote and possibly invisible regions. Also links of interconnection between other systems and our own may yet be found, and made to tell their secrets. It should be added that recently a couple of stars have been endowed with a velocity greater than even that of 1830 Groombridge, but the correctness of their parallaxes has been doubted. At any rate, if the above theory holds good, there are stars possessing sufficient motion to dash across the interstellar boundaries, which seem so permanent and impassible for our Solar System and those adjoining. Naturally the question rises, how is such an extraordinary velocity gotten at the start? and whence? Possibly some other visitor will tell something more if he can be detected.

Here we must withdraw our short glance at the

distinctively stellar world, the separated Pancosmos as we name it in the total sweep of the Systemic Cosmos. We are now to advance out of this vast separation, which cut up the physical universe into what may be deemed its primal visible units, whose evolution we have watched in the nebula. Next we are to take one of these evolved units and to behold it in its organic details, making it the standard of comparison and the measure of all the other stellar units of the Pancosmos. Thus we get to know the one typical individual of the skies, and through him specially we seek to know the rest. The Sun with his system unfolded as we behold it, becomes in this way the measurer, the organizer, the systemizer of the Systemic Cosmos, of which it is the final-development. That is, the universal but unordered Pancosmus has unfolded its ordering individual in the Solar System, of which fact we may hear an echo in the common statement that each star is a sun with its planets.

III.

The Sun.

The work of Copernicus in transferring the center of our planetary system from the Earth to the Sun has been long regarded as the supreme deed of astronomical science. But its significance reaches much farther: it compels the human mind to construct anew the universe, not after the senses but

after thought. For through its training our spirit becomes heliocentric, being no longer merely geocentric. We must perform the great act of estrangement from our immediate Earth and take our standpoint in the Sun, viewing the Cosmos not so much physically as ideally, not so much by means of light as from the very source of light. It unfolds in us new eyes, it forces us to look with a second sight in order to see truly our own world. Along with the Copernican theory arose a desperate religious encounter about which much has been said. As science has certainly won in that fight with the church, it is time to have a little peace on the subject, and so we shall here pass it over. But the psychologic act of rising from this particular terrestrial sensuous sight to a universal mental vision of the physical All cannot be too highly appreciated. That act we teach our children in the Public School to perform, and thus make it an integral element of human consciousness.

Modern science has begun to carry the idea of Copernicus far beyond its original limits. The Sun is found actually to move, yea to be revolving around a center in its turn; not the seeming terrestrial one, but the far-off galactic or even cosmical one, of which some account has already been given. But it should be noted that our immediate sensuous view of a revolving Sun bears the impress of the ultimate fact of the Solar System; our great luminary is whirling through the skies in a circle.

So in a manner through Copernicanism we are coming back to our first naive look at the Heavens, which first look, however, has been widened to a vision of the universe.

Accordingly we have reached the Sun with its System as the final outcome of the Systemic Cosmos, the last stage thereof, the typical cosmical individual which has been generated as its final product. Not only is there a solar system, but also a solar organism of which science has recently unfolded many a surprising secret. Indeed we are just now getting acquainted with his majesty the Sun himself. So the great luminary has his own corporeal system besides the planetary, the latter being properly his offspring and constituting his family.

The Sun we are to take, then, as the central genetic unit, the unit from which all its individual followers have sprung, and it still shows many signs of this its originative function. Children and grandchildren, planets and their satellites it has, and perhaps more remote descendants; and it is still in vigorous activity. As to the life of the Sun, scientists generally seem to believe that it is about half sped, though some say more than half and some say less. One thing seems pretty certain: it is no longer productive, that is, planet-begetting; in this sense its creative time appears to be past. It looks as if the Solar System as such is finished, being at high noon, possibly a little before or a little after.

But the Sun's own System is still mightily alive, and is still the source of life and action to all its supposed offspring, who depend upon the parent like members of one body. Through gravitation it holds them to themselves and to itself; through heat, light and electricity it furnishes the basic forces underlying all their individual energies. Indeed the Sun acts now as a kind of power-house to the entire planetary system to keep it going; if it no longer generates planets, it generates the energy largely by which they move and live. It furnishes as it were from its heat the blood which circulates not only through its own body (often with tremendous violence), but also through the whole planetary system, making the same a single organic whole or systemic unit.

The Sun's diameter is 866,500 miles, which is about 110 times as great as that of the Earth. The force of gravity on the surface of the Sun is nearly 28 times as great as that on the surface of the Earth. It is supposed that an ordinary man weighing 150 pounds, transported thither, would be crushed by his weight and sink down with broken bones, if nothing else happened to him. This overwhelming gravity of the Sun increasing toward the center by superincumbent pressure, is a very important item in the process of the solar body as we shall see.

The mass of the Sun is 324,000 times as great as that of the Earth, but its volume is not in proportion, since the density of the Earth is estimated to

be about four times as great as that of the Sun. The Earth being so much smaller has cooled off far more rapidly since the time of its original separation from the Sun, whose volume is calculated to be more than 1,250,000 times as great as that of the Earth. Thus the Sun is much nearer its original nebular condition—for instance, its condition when it was a spiral ejecting planets—than the Earth. The difference between their respective masses and volumes has this meaning. We may suppose that when the Earth was thrown off, its density and temperature were pretty nearly the same as those of the ejecting body, though not quite. Another important comparative fact in this connection is that the Sun is computed to be nearly 800 times as great, that is, as massive, as all the planets combined. Since gravitation depends upon mass, we see how much strength the Sun has kept for himself—far more than that of all his children together, if they should ever try to pull against him—which indeed they would do if lured by a mightier outside power. Ready to revolt they must be to the stronger Sun. We, therefore, imagine a rim of the Solar System where it joins the domain of its next neighbor. The firmament must be full of these imaginary limits which each particular Solar System (or star) draws around its possessions—the fenced-off farms of the skies. Our Sun is also a monocrat in character, we may think; at least he never divided himself and became two Suns—

which seems to have been the case with his nearest solar companion, Alpha Centauri, whose system is apparently a kind of dyarchy—two central luminaries revolving around each other.

The average distance of the Earth from the Sun is now put down at 92 to 93 millions of millions of miles. This measurement is derived from observations taken at the transit of Venus across the solar disc. Several other ways have been devised by astronomers. The distance of the Earth from the Sun becomes important, since it is employed as a unit of measure for marking off (with a kind of surveyor's chain) the enormous spaces of the Cosmos (the so-called astronomical unit). Neptune, the outermost planet yet discovered, is distant from the central luminary 30 such units, and Alpha Centauri, the nearest star, 275,000, that is, so many times 92 millions of miles. This unit of measure of the physical universe should be ascertained with the greatest possible precision and it is still being overhauled by astronomers. Some years ago it stood in the text books 95 millions of miles, but that figure has been shown to be too large. It may be said of all these huge measurements that they are given with slight variations by different authors. Still there is substantial agreement except in one case, that pertaining to the degree of the Sun's heat on its surface. Pouillet says 1600 degrees Centigrade, Rossetti 10,000, Secchi 10,000,000 (as reported by Flammarion).

The general belief among scientists, as far as we have been able to trace it, places the Sun's heat at about 8 to 10,000 degrees Centigrade, though it must differ a good deal in different localities. The heat of the sun is the original driving power of the Solar System, but it has not yet been caught and utilized by machinery. The solar engine is yet in its infancy. A distinguished scientist declares that the noontide heat of a summer Sun beating down upon the area of Manhattan Island, would "drive all the steam engines of the world." The Sun is truly the vast reservoir of systemic power which will be one day directly tapped by the children of Earth.

The velocity of light is pretty well settled to be 186,000 miles per second. The credit of its first ascertainment belongs to a young Dane, Olaus Roemer. At the Paris Observatory (about 1675) he made the pivotal observation that the eclipses of Jupiter's moons are seen later where the Earth is farthest from Jupiter, than when the Earth is nearest. He inferred correctly that this difference arose from the time required by light for traversing the Earth's orbit, whose total circuit measures 584 millions of miles. As this orbit is an ellipse the distance across its area varies. The Earth is about three millions of miles nearer the sun when in perihelion than when in aphelion. Now this measurement of the speed of the Sun's light was a great achievement in science. The inference was

at once made that not only sunlight, but starlight, nebular light, in fine all light moves at the same rate. As far as known this inference has never been gainsaid. The result is that cosmical light, traversing enormous distances is not instantaneous, as it is practically on the Earth. We look at the satellite of Jupiter, we see it as it was half an hour since, not as it is now. The light of a near-by star may be only five years old, that of a far-off star may be five thousand years old.

If our instruments ever become so perfect that we can see what is taking place on a distant star, the event may be already centuries old. In like manner from our planet, light flashing through space for twenty-four hundred years may be just bringing to some remote eyesight a view of the battle of Marathon. Certainly light bears to me through space and in time the impress of yonder mountain or of yonder man chopping down a tree. Why should it not be carrying the whole picture of universal History in its radiance through the Cosmosphere? Of course that is yet to be proved. Possibly it may yet be made, by some device, to deliver up the entire panorama of the past which it has seen (humanly speaking), and which appears to be somehow contained in it. Moreover, light coming from opposite directions and all directions, does not seem to collide with itself, but always slips through its own counter undulations at the same rate of speed. The luminous waves from

millions of stars must cross but do not interfere apparently with one another at meeting. Such are some of the problems or at least imaginings which the measurement of the velocity of light suggests.

The Sun is slowly contracting through its loss of heat by radiation. The vast amount of this radiation is indicated by the fact that the Earth receives of solar heat only one part in two thousand millions. The calculation was made by two scientists, Pouillet and Sir John Herschel, who practically agreed in their results, though each worked independently of the other—the one being in Paris and the other in South Africa. But how is this enormous quantity of heat generated, seemingly for millions of years, with no sensible diminution of its power as far as yet observed? The generally accepted theory is that of Helmholtz, which ascribes to the contraction of the Sun its ever-renewed heat. Indeed, the assertion is made that the Sun is actually getting hotter in spite of its thermal loss, that contraction overbalances at present the dissipation. Gravity with its pressure is thus converted into a radiant energy.

It is at this point that we may catch the main process of the Sun, its double action inwards and outwards, a kind of systole and diastole of the heart of our world. We have already noted the pressure on the surface of the Sun to be twenty-eight times greater than that on our Earth. The internal material of the Sun is supposed to be

gaseous in form, though by the enormous condensation reduced to the consistency of tar or honey. But the expansive energy of the gas through heat is not destroyed, rather is it vastly intensified and breaks through the superincumbent weight. Here then we find the two conflicting forces whose desperate battle may be witnessed in the colossal agitations so often observed in the Sun—the whirling and changing spots and faculæ, the volcanic upheavals and protuberances, the jets of gas flaring up from the surface many thousands, perchance millions of miles. Gravitation on the one hand, with its pressure toward the center, radiation on the other hand with its propulsion outwards from the center—these are the mighty agencies embattled in the Sun and struggling against each other. It is the primordial dualism of the Cosmos and Diacosmos concentrated in the central body of our Solar System. The grand opposite or enemy of the cosmical principle has appeared and has grappled with its antagonist at the source. Soon we shall have to consider this antagonist, the Diacosmos, in his own right. At present, however, we must put into its main outlines the total System of the Sun; we might call it the Systemic Sun, embracing the solar organism, the planetary and the interplanetary bodies.

It is evident that a much larger quantity of astronomical material lies in this field than in any other portion of the science. How should it be

ordered? Can we make the basic process shine through the mass? First we may regard the Sun in its cosmical aspect, as endowed with the elements of the Cosmos; secondly, the Sun unfolds the planets out of itself, certainly its act of separation; thirdly, the Sun must be considered in its diacosmical aspect, asserting itself outwards by a repellent or radiant energy, as well inwards by attraction.

I. Cosmical. Assuredly our great central luminary is a member of the Cosmos as a whole, and partakes of the cosmical character. If a glance is cast back to the beginning of this book, we find its earliest portion to pertain to the elements of the Cosmos. These are three—Motion, Matter, Measure—those universal ideal principles which always seem to rise up in advance of their real forms of manifestation. The Solar System must then be first considered in this its original elemental aspect.

1. *Motion.* The sun still rotates on its axis, such being doubtless its primordial motion as Heliosphere, yea, the primordial Motion of the physical universe. It performs this axial rotation in about 25 days; that is, to one solar revolution the earth makes twenty-five revolutions. But the sun's diameter is more than a hundred times that of the earth; the result must be that the solar surface whirls much more rapidly than the terrestrial surface. But now comes the very suggestive fact: the surface of the sun does not rotate in one piece

(like the earth), but varies in each latitude, with velocity decreasing from the equator to the poles. We are to remember that the density of the sun is four times less than that of the earth, one fourth more than water. Then the solar rotary velocity is much greater than the terrestrial. Thus we have one source of the great agitation always witnessed on the solar surface. The mighty struggle between Gravitation and Rotation never ceases, though it varies. This must produce collisions of matter which generates heat and intensifies expansion. On the other hand there must be some cooling process in the sun itself; possibly it lies in that slower movement of the solar material toward the poles. The sun-spots are more numerous near the sun's equator, on each side of which they move in two nearly parallel zones. These spots show fusion of what appears a darker and cooler mass, which is in the process of being again melted. Colossal are these solar convulsions, and their details as well as their causes are not well known; but in general we have to conceive them as the ever-active throes of the sun in planet-making. The sun-spots suggest little planetoids which are always being produced, but always falling back into their source. The prominences, the eruptions, the jets of flame reaching 142,000 miles from the solar body, indicate the terrific effort of the sun still to bear worlds. But it would seem that the period of her procreative energy is past. We shall probably not witness the

birth of another planet, yet there can be little doubt that many phenomena of planetogenesis can be observed in the solar activities. Thus some of the early events of our terrestrial evolution are taking place today on their original stage.

Accordingly the sun has a common axial motion which splits up into many motions on its surface. But the sun has also an orbital motion which is carrying it through the celestial spaces. This fact has been already noted.

2. *Matter.* This is the second cosmical element. The Matter of the solar organism manifests attraction through gravitation, whose limit doubtless extends to the boundary lines of its adjoining stellar neighbors. Of these the nearest is Alpha of the Centaur (see preceding p. 268). On the other hand the sun has a repellent power which springs from its axial rotation, and which constitutes its separative or creative activity (see preceding p. 263). Motion as rotatory shows itself the Separating in regard to Matter which through it becomes the Separated (for this distinction see preceding p. 12, 40). We may well deem this rotatory ejection of Matter as the first form of radiation, which is to attain such prominence later in the Diacosmos. Matter is indeed to become self luminous, ever separating from itself and raying forth afar through the celestial spaces.

3. *Measure.* It has been set forth that Motion and Matter are inherently quantitative, and so can

be and indeed must be measured. The first great act of cosmical measurement is found in Newton's law of gravitation. Though it was enounced after Kepler's three laws and was probably derived from one of them, it is more simple and more universal than they are; we, therefore, place it at the start of the present stage. Kepler should come next with his famous three laws, of which the first declares the orbits of planets to be elliptical, the second affirms the proportion between the areas and times of the radius vector, the third connects all planetary orbits in stating that the squares of the periodic times of planets are to each other as the cubes of their distances from the sun. A chief interest of these three Keplerian laws is that they constitute together a totality in which we may see a process. The first grasps the one outer basic form of all orbits, unifying their diversity; the second deals with the inner differences of the same orbital round of the planet, finding their common measure by means of the radius vector; the third embraces all orbits (herein it is like the first law) and formulates their common measure which indicates their one basic principle (herein it is like the second). Such is their process moving from outer form to inner character, and putting under the unity of law the varied and confusing orbital phenomena. Kepler has quantified the solar system, running geometric lines through it and formulating arithmetically its proportions. To the Motion of planetary Matter

he has given Measure, and thus revealed the full round of the elemental Cosmos in his particular field. Immortal fame he deserves for putting order into our sun-world, and probably he has furnished the basic conception for ordering other solar systems, even the binary and ternary.

There is a third law or principle belonging to the present subject, upon which recent astronomers have placed much stress: it is named usually the conservation of the moment of momentum (not the conservation of energy). The momentum of a body is its mass multiplied by its velocity (*mv*); if it be moving in a plane about a center, the product of the radius or perpendicular into the momentum is invariable. This principle has come into prominence in order to find the unity in the vast changes produced by shrinkage of the sun and planets and worlds. The moment of momentum remains the same whatever be the alterations of the radius and the momentum: they are variable but their product is invariable. Here then we have the common principle in all the mutations of cosmical evolution.

The law of gravitation implies the tendency of all bodies toward unification and measures the same; the Keplerian laws imply rotation combined with gravitation in the diverse planetary orbits and measure these orbits; the conservation of the moment of momentum assumes not the sameness and permanence of bodies and their motion (as do

Newton and Kepler), but the vast evolutionary changes of world-formation, and expresses the constant principle which pervades and unifies all these changes.

The mathematical details of these measurements must be here omitted. But in a general way we can see that the Measure of the Motion of Matter has been manifested specially in the Solar System, that the three elemental principles of the Cosmos have been shown in a particular process, which is probably typical of all other worlds of the cosmical system.

II. PLANETARY. It is pretty generally agreed that the planets have been separated from the Sun, or from the primordial Heliosphere, and thus they represent the deepest separative act or stage of the Solar System. It may be said that the Sun has particularized himself in the Planets, in accord with the analogous case of the total Cosmos already set forth (see Particularized Cosmos). Another analogy is the genetic: the planets may be deemed the children of the sun, showing many characteristics derived from the parent, and they still belong emphatically to his family, being held in unity by a kind of affection called gravitation. Their evolution from the Heliosphere has been already given, through which come to them certain endowments from higher sources. Says Prof. Ball: The Solar System "commences with a certain endowment of energy, with a certain endow-

ment of the moment of momentum, and with a certain principal plane to which that moment of momentum is related" (*The Earth's Beginning*, p. 229). Such are the three transmitted gifts according to the famous astronomer. The whole planetary retinue moves in the same general plane with the sun (not counting two or three small lunar exceptions), and in the same direction, just as whirled off originally from the Heliosphere. But whence did the latter get its rotatory motion and its degree of energy? That has been already sufficiently discussed; at present we shall seek the order of the planets which move in a succession of orbits or rings around the Sun, suggesting the concentric layers of the original spiral nebula.

There are, however, many unsettled anomalies in the Planetary System, which render a perfectly transparent ordering of it as yet impossible. Then our knowledge of it is deficient in certain important matters. The outermost planets seem the least developed, yet they must have been mechanically the first thrown off in the nebular genesis of our system. It would seem, then, that evolution has been far more rapid in the case of some planets than in others; indeed the last born appear to be the first matured and perchance the first dead. But this whole subject is still uncertain. We shall, however begin with the interior group of Planets (Mercury and Venus); then glance at the middle group (Earth, Mars, Planetoids and Jupiter the huge

transitional Planet); finally consider their exterior group (Jupiter, Saturn, Uranus, and Neptune). This seems the best way to grasp the planetary order as it exists before us at present, though the line of its evolution in time may have been the reverse.

Having made the three groups aforesaid, we are next to seek the deepest ground for distinguishing them. Such a ground lies to our mind, in the original world-creating act itself through which planets and also their satellites came into being. The Sun begets the Planet and the Planet begets the Moon; all these children and grandchildren will show their common descent, yet likewise different degrees of variation which will furnish criteria for grouping them.

1. *The Interior Group.* Mercury is the planet nearest to the Sun: the time of its axial revolution is about 88 days, which is also the time of its orbital revolution. Thus it moves about the Sun as the Moon moves about the Earth. After Mercury comes Venus, whose axial and orbital revolutions occur in the same time, nearly 225 days. Herein it is similar to Mercury.

This seems to be the basic fact which distinguishes these two planets from all others of the Solar System. It has been named the isochronism of their two circular movements, axial and orbital. Thus they are relatively the two satellites of the Sun, and they have no satellites of their own—wherein

they are unique among the planets. Such is the general character which groups them by themselves. From this point of view they are the least differentiated from their solar parent, the least individualized of the planetary members, always turning the same face toward him and the least removed spatially from him. Also, there is no separation strictly between the day and the year (just as our moon's day is the month); they have no day of their own, produced by their own distinctive revolution, though of course they turn on their axes and in their own time, both their periods being different from that of the Sun, which is 25 of our days. Thus they are separated in their axial motions which however remain the same in time with their orbital motions. Each of them has a very hot front, a face in perpetual sunshine, and each a very cold hinder face in eternal night. Just as we see only one side of the Moon, so the Sun sees only one side of Venus and Mercury. The inference lies near that they can not be inhabited, at least by any beings like ourselves. At the same time they are marked by strong individual differences which need not be recounted here.

And now let it be announced that the foregoing statements are by no means accepted by all astronomers. It was the Italian Schiaparelli who first discovered and formulated the principle of planetary isochronism, starting with his observations on Mercury in 1882 and concluding with those on

Venus in 1895. Before his time we had always read in the books that the length of the day of Venus was about the same as ours, but now we are told that it lasts more than 224 of our days. The crystallized scientists were shocked by the new idea, veritably revolutionary, which, however, has not failed to advance steadily toward supremacy. An American astronomer, Prof. Percival Lowell, from his observatory at Flagstaff, Arizona, has confirmed the chief results of Schiaparelli.

Another point should be noted in this connection: the existence of one or more planets between Mercury and the Sun. Especially that unborn, but baptized and named Vulcan has a curious little history. Leverrier calculated the existence and even the position of the outermost planet Neptune from the perturbations of other known planets, and was famously rewarded by its discovery. From that time (1846) to this the mathematicians especially have not failed to trumpet their triumph: our science is the true prophet of Nature. But now for the counter stroke. Leverrier, from the perturbations of Mercury, concluded that there was an innermost planet (as well as outermost) and started to find it through calculation. At last he announced that "Vulcan would cross the solar disc March 22, 1877." But it was not then or afterwards seen. About this fact there has been no exultant blare of trumpets, though it be a curious and seemingly necessary counterpart of Nep-

tune s discovery. We have found the story only in Flammarion, who, though a great astronomer and mathematician, did not like Leverrier, his fellow-laborer and fellow-countryman (on account of some snub, as we gather it).

2. *The Middle Group.* With the Earth a distinct Group of Planets begin, which have evolved out of isochronism, or out of the lunar condition in relation to the Sun. A more independent planetary individuality comes to view, a greater separation from the solar parent. The axial and orbital motions of the Earth are now differenced in time, the one taking a little less than 24 hours, the other a little more than 365 days. Not only does the Earth refuse to be a moon to the Sun, but it has evolved its own moon; that is, it has itself become genetically a kind of Sun, begetting its satellite. Thus the first group (as sun and planet) has reproduced itself in the second planet (as earth and moon). Such is the deeply characteristic change which now takes place.

The next planet is Mars, which also has dropped or doubtless transcended the principle of isochronism. Its time of axial revolution is 24 hours plus, its orbital year is 686 days plus. Herein it is like the Earth as to character. Also it has produced moons, not one, but two (Deimos and Phobos). These were discovered by Professor Asaph Hall at the Observatory of Washington in 1877 and produced another ferment among the staid astrono-

mers who had settled down to the time-honored dogma that "Mars has no satellites." It is a curious fact, however, that Dean Swift in his "Gulliver's Travels," assigned two moons to the planet, Mars, more than 150 years before they were discovered. Voltaire repeated the same fancy in his satirical romance, "Micromegas," some 30 years after Swift. Thus poetic imagination had seen the two Martian satellites long before the telescope had brought them into the range of the outer eye. (The two passages from Swift and Voltaire are cited in Flammarion's *Popular Astronomy*, translated by Gore, p. 395-6.)

But we are not yet done with the two moons of Mars, which are instances of the pivotal genetic principle of systemic evolution. They are very small, probably less than ten miles in diameter; their orbits are nearly circular and they revolve around Mars nearly in the plane of his equator, which corresponds to that of the total Solar System (with a few exceptions). The outer satellite makes its revolution in a little more than thirty hours, while the planet rotates on its own axis in 24 plus hours—which constitutes a striking difference from our Moon-Earth system. But far more striking is the fact that the second satellite (Phobos) makes its revolution around Mars in a little more than seven and a half hours; that is, in less than one-third of the time of the axial revolution of the planet itself. Imagine a little moon whirling

round our Earth three times a day at a distance of less than 4000 miles (the distance of the outer planet from the surface of Mars is set down at 12,600 miles). Such is the marvelous diversity from the Earth's satellitic system! But there is lacking apparently the keystone of knowledge in the present case: that pertaining to the isochronism of these two moons. Nobody, as far as our search has extended, has yet been able to detect their axial motions, doubtless on account of their extreme smallness. Therefore it is not known whether their orbital round is synchronous with their axial. But little Phobos (Terror) has struck terror into the whole nebular hypothesis by its excessive and unaccountable velocity around its primary source.

In recent years the planet Mars has attracted much attention, more than any other planetary member of the system. It has changes of color and different tints on its surface; it has peculiar markings conjectured to be canals and seas and oases, some of which are supposed to be artificial; it has some good claims to be inhabited. This special interest in Mars was started by Schiaparelli, but has been kept up and furthered by the work of Prof. Percival Lowell. But of these matters we can here take no account.

After Mars follow the so-called Asteroids (or Planetoids), the first of which was discovered by Piazzi at Palermo on January 1st, 1801, the first day of the new century whose very suggestive sym-

bol these Planetoids may be regarded. The system seems here to break into a vast separation and multiplicity; the number of them discovered can not be far from 500 at present (perhaps more), and gives promise of running out toward infinity. Very early the conjecture was started (by Olbers) that they were the fragments of an exploded planet; but they were doubtless thrown off by the evolving and revolving Heliosphere (like drops from a rapidly whirling wheel) and were never allowed to coalesce into a planet by the mighty attractive power of Jupiter, which is still acting like a tidal energy, and keeping them separate. According to Bode's law there should be a planet between Mars and Jupiter whose size even has been calculated by astronomers. There is a large vacant space between the Planetoids and Jupiter, who in times past may have swallowed many of these tiny fishes of the solar sea. At any rate the Sun must have whirled them off and set them to spinning, while huge Jupiter prevented them from consolidating. It is evident that Jupiter in this case works like a second sun, which he is sometimes called.

It is a question whether Jupiter belongs to the middle or outer group of planets. On the whole its system of satellites seems to correspond to those of Earth and Mars, though there is a considerable increase of number. The peculiarity of Jupiter is his enormous mass, which is more than twice as much as all the rest of the planets put together.

In this and other respects he has been compared to the Sun. He rotates on his axis in less than ten hours, which means a prodigious velocity at the equator. The density of Jupiter is a little greater than that of water, and nearly the same as that of the Sun. The result is that different latitudes rotate differently—a phenomenon which is also solar. There is no doubt that Jupiter is in a less advanced stage of development than the smaller planets; in fact he has thrown off satellites which are supposed to be in a more matured condition than he is, and possibly to be inhabited—which is not his case. Thus Jupiter must have been much the largest mass of nebula that ever separated from the Heliosphere in the formation of the system. This planet is still cooling, though still quite liquid; seemingly it is not self-luminous. It has doubtless passed its period of moon-making, its reproductive time is gone, in spite of the struggles noticeable on its surface. A similar fact was observed concerning the Sun. It has begotten nearly as many satellites as the Sun has begotten planets; moreover, there is a largest satellite of its lunar family comparable to itself both as to size and position in the planetary family. Thus the Sun has most completely reproduced himself in Jupiter, who is now declared to have seven moons, two of them photographic.

3. *The Exterior Group.* The line of Planets might be divided at or even through Jupiter, whose

very magnitude can be taken as a boundary between those before and those after. He is a second center of the system, exercising a secondary control over a vast number of comets, of planetoids, and doubtless of other kinds of unseen interplanetary matter. But when we regard his satellitic system, it seems definitely finished like that of the Earth and Mars, to which Jupiter is in this fact allied. On the other hand, when we turn to the next planet, Saturn, the evidence is that his satellitic system is not completed, but is still in the process. The rings differentiate Saturn very strikingly from all the preceding planets, and compel a new group. It has an annular system as well as a lunar. These rings are composed of small particles revolving together around their planetary center, though the revolution is faster on the inside than on the outside of the rings. The particles are essentially small moons, each with its own orbital and probably axial motion, though the latter of course cannot be observed. In addition to the rings Saturn has ten satellites, two of them photographic. Others will probably be found. Saturn, therefore, is in a certain stage of moon-making, and reveals probably what other planets have gone through. It has rings, satellites and seemingly satelloids.

In regard to the body of Saturn, it has much less density than Jupiter, being one-eighth of that of the Earth. It is, therefore, nearer to the original nebular mass of the Heliosphere from which it once

separated. Its distance from the Sun is 866 millions of miles, and it receives a proportionally small amount of solar heat; but its own heat makes it "thermally self-supporting." Its axial rotation is very rapid, taking place in ten and a quarter hours; while its orbital revolution is slow as compared to the preceding planets. On the whole Saturn manifests a very early stage of planetary evolution.

After Saturn comes Uranus, discovered by Herschel in 1781. It is very hot, not from the Sun, but from itself; too hot to allow water to be formed on its surface. It must accordingly be in a gaseous condition; hydrogen and oxygen are probably present, but cannot combine. Still the striking fact about it lies in the peculiar motion of its four moons, they together revolve in the same plane and in the same direction, but almost at right angles to the plane of the ecliptic (at 83 degrees) and retrograde to the whole previous movement of the solar system—sun, planets and satellites. This deviation, or rather defiance of what seems established systemic law, has produced much wondering and conjecture, and has given comfort to the revolutionists. Not one exceptional moon but four of them turn here according to some regulation of their own, which they obey in common while they disobey not only their own planetary parent but the adjustment of the whole solar family. It is declared, however, that the single moon of the outermost planet, Neptune, is guilty of the same violation.

The exterior group of planets shows an altogether new stage of their genetic act in the production of satellites. The first bodies thrown off by the Heliosphere—Uranus and Neptune, as far as we know—had their own lunar development. It is possible that these refractory moons are the primordial ejects of a neighboring system, but have been picked up by our border planets and united to our system, though retaining their original motion as satellitic. Thus we may for the nonce keep the nebular hypothesis, which has been badly shaken up and some think, shattered, by those far-off moons of Uranus and Neptune. That frontier line can probably be crossed under conditions which have indeed yet to be investigated.

Between the orbit of our extreme Planet Neptune and the boundary of the Solar System toward the nearest star (Alpha Centauri) lies an enormous stretch of space, more than 4,000 times the distance of the Sun to Neptune. This is the vast field of extra-Neptunian Planets, still undiscovered but supposed to exist. The example of Leverrier's success has been a powerful stimulus to astronomers (see preceding p. 271). Symmetrically there is an intra-Mercurial domain to be explored.

In his deservedly popular book, *The Earth's Beginning,* says Prof. Ball: "The movements of the satellites of Uranus and Neptune do not disprove the nebular hypothesis. They rather illustrate the fact that the great evolution which has wrought

the solar system into form has not yet finished its work. . . . When that work shall have been completed, the satellites of Uranus and Neptune will no longer be dissociated from the general concord" (p. 347). There may be well some question about this remote result; but the real difficulty can be stated in the interrogation: How did these strange exceptions get to be out there on the frontier of our world? The genetic problem is the one which faces us now and with which we are dealing. We have to think that if the moons of Uranus and Neptune had been thrown off by our Heliosphere, they would have conformed to the general motion and angular inclination of the System. But their exceptional position and movement could only have sprung of an adjoining Heliosphere from which they have been deflected by Gravitation, though preserving their original endowment of motion.

Apart from these anomalies on the border, our solar System shows a remarkable symmetry throughout. The orbits are ellipses, though varying, and lie in nearly the same plane; sun, planets and satellites revolve in the same direction (with the exceptions already noted); their planes of rotation (axial) nearly coincide with their orbital planes, and so with one another; they all rotate in the same direction (as far as can be seen). This essential sameness of revolution, rotation and direction implies sameness of origin; the difference

in these regards on the border can only imply a difference of origin.

It would seem, then, that in the system-making of our Heliosphere, we have come upon bodies which the latter did not evolve. With this phenomenon rises that of the comets which are often supposed to have a foreign origin, even if naturalized in our Solar System. In general, however, our Heliosphere has begotten its children and grandchildren, and kept them within the family. Or, in other phrase, we have seen the triple process at work: (1) original axial rotation; (2) radial energy ejecting bodies which then fly off tangentially (the whole is often called centrifugal force) ;(3) orbital revolution of these ejected bodies, caused by gravitation (centripetal). Evidently planetary evolution has been a colossal struggle between Rotation and Gravitation, with a kind of compromise which has kept the separated bodies revolving in the one system. Thus the separation is preserved yet is also counteracted; Gravitation turns back to the central body the rotating planet from its radial sweep outwards, and ends the planetary process.

III. Diacosmical. Not a new Sun, but a new act of him now appears, different from the gravitational, which has hitherto dominated the Cosmos. We have just seen how he controls with his mass the planets which he has ejected in smaller masses. But now the Sun begins to show himself as degrav-

itational, undoing gravitation in himself, and manifesting self-luminosity, which is a persistent radiation of himself in opposition to attraction. In this stage he may be said to be ejecting not planets but himself; he is supremely radiative, self-repellent, self-separative; he is no longer cosmical but diacosmical. That is, through our central luminary we are passing out of the Cosmos into the Diacosmos, from a world essentially centripetal to a world essentially centrifugal, from the unitary to the separative stage of total Nature. The planets are not self-luminous or self-ejective, or only so to a small degree; they largely receive from the outside their heat and light, though they were born of the Sun and may once have been more radiant than now. Through the Sun, or perchance through the Suns, Nature becomes diacosmical and is to be investigated on this side, namely on the side of her radiant energy. That is, however, her next great stage of development which we are soon to take up.

In reference to the Diacosmical Sun, we may in the first place regard it as the systemic reservoir of the mighty outpushing energy of our physical world—the energy which separates, atomizes, degravitates, and which we find in us and around us everywhere, having received it in some way from its fountain-head. In the second place this Sun is radiant, yea self-radiant and self-repellent quite to infinity, as we now may recognize by the photo-

graphic plate revealing an invisible stellar universe. In the third place it has recently been discovered that this Sun (or Suns) must be taken as the original laboratory from which proceed all the diverse chemical elements, which are also, it would seem, to be put into a line of evolution.

Our Diacosmical Sun, however, in its present stage, is not the earliest forge of elemental matter, if there be found in it thirty-six different chemical elements, as has been stated.

It is evident that our systemic Cosmos nas now been brought to a conclusion, since its ultimate principle has been reversed in a new order. Still further, the Cosmos as such, as has here been conceived, is distinctly transcended. It has unfolded hitherto its unity, and is held together by the attraction of its separate bodies, which shows the overcoming of all separation in a final unitary system, the solar. The outcome of the Cosmos is the systemic plan of the physical universe; this plan we have seen unfolding in Sun, Planets, and Satellites, to which may be added other lesser systemic forms. The three stages, called here the Elemental, Particularized and Systemic Cosmos, have run their course, each being a part of the greater movement of the Cosmos, yet each having its own special movement within itself.

We have reached the point at which we behold the Diacosmical Sun ejecting himself in a vast diversity, dividing himself to an indefinite smallness,

and thus uttering (or outering) himself in a new way. The unity of Body in his case starts to fly asunder, his cohesive individuality begins to dissolve itself and therewith to dissolve all corporeal existence, (for instance in his heat). Now this world of activity we intend to look at as it is in itself, distinct from its source. So we pass to the Diacosmos from the Diacosmical Sun, which, as we regard it, is the final manifestation and transition of the Cosmos.

PART SECOND.

THE DIACOSMOS.

The strangeness of this word *Diacosmos* was briefly remarked in the opening sentences of this book. A few observations in regard to it may now be added to what was there said. It is a linguistic need for ordering properly the total realm of Natural Science, as we see the subject. So we are driven to dig up and resuscitate a term of the old Greek philosopher, Democritus, endowing it with new though cognate significance, and making it stand for one of the three grand divisions of total Nature. Diacosmos, by its etymology, suggests the separative stage of the cosmical order, separating from the Cosmos, and separating within itself also. This characteristic we shall find running through it from beginning to end. The term *Physics* is com-

monly employed for designating this department of science, leaving out Chemistry and adding somewhat of Mechanics; but there are serious objections to the word, though in some instances it will have to be employed. The title in our school-days for this branch, *Natural Philosophy*, seems to have lapsed from usage, though it has the sanction of Newton's great work (*Principia Philosophiæ Naturalis*). It is stated by Diogenes Laertius (*Vit. Phil.*, Book VI) that Democritus was the author of a treatise called the Little Diacosmos, in which his doctrine is set forth. That doctrine pertained to the atom, which has likewise been revived and newly applied during the last hundred years, especially in chemistry. Democritus was verily a searcher for the ultimate element of things in Nature, which was for him the atom. His spirit, accordingly, was in marvelous consonance with the spirit of to-day's physical science, an ancient prophecy of which was forecast in his philosophic conceptions. Possibly the credit of priority may be due to his teacher, Leucippus, often declared the originator of atomism. It should be added that another work called the Great Diacosmos was attributed to Democritus, but its authenticity was questioned already in antiquity. Having the thing, we shall use the word, for the atom both ancient and modern is truly diacosmical.

Undoubtedly we shall have to make the Diacosmos include far more than the atom, by way of

contrast with and reaction against the Cosmos. For instance water no longer holds together with any degree of cohesion, its molecules separate easily, are quite indifferent to one another; we may deem it Matter loosened up within and ready to go asunder; in this aspect water is diacosmical, indeed the first and basic liquid of the Diacosmos. Heat radiates from a center outward in opposition to gravitation; it is, therefore, diacosmical as well as Light. If a glass rod be rubbed by a piece of catskin, it will attract a pithball, or other light object held near it; that is, a new attraction overcomes the earth's attraction and controls the same for a time; so we have to think that a diacosmical power, Electricity, grapples with and triumphs over a previous cosmical power. Then the movement of Chemism from the compound to the element, from the element to the atom, from the atom to the ion, corpuscle, electron, is profoundly separative and diacosmical. Such is a hint of the vast sweep of the Diacosmos, as well as of its general character, all of whose phenomena we shall seek to organize in one great totality with its duly ordered divisions, reaching from the simply uncohesive molecules of the fluid at the start to the complete disintegration of the physical universe through Chemism into its diacosmical dust, whose last and finest particle is called the electron or perchance the etherion (on which there will be more to say hereafter).

We are, therefore, to emphasize in our thought of the Diacosmos, that it is the active opposite of the Cosmos, the negation of the same in a certain degree, the pronounced reaction against cosmical properties and forces. For example gravitation is regarded as the dominant universal energy of the physical universe extending to its remotest nebulæ. Yet gravitation is contradicted by the gas, by heat, by magnetism, in fine by the whole realm of radiation. Still further, the cohesion of the solid as cosmical is broken up by the complete separability of the liquid as diacosmical. Cohesion holds the body together and keeps it from dissolution; it is the preserver of cosmical individuality. Upon this cohesion is the first assault of the Diacosmos, seeking to break the chains by which it holds so tightly together the molecules of the solid, resisting their separation into liquifaction. Besides cohesion, the inertia of body or its resistance to Motion is assailed by the diacosmical energy in a number of ways. The inert body resists its own return to a state of rest when once in movement; it persists in being what it is, staying or going. In radium, an otherwise inert element seems to possess an indefinite power of self-radiation, of throwing itself away without losing any of itself, or very little; it shows a marvelous motion while remaining at rest.

If gravitation be taken as the pervasive, universal character of the Cosmos, we naturally seek for

the similar universal fact of the Diacosmos. Or we may put the query in this way: What is the salient all-ordering category of the whole realm of the Diacosmos? Or is there any? Certainly no unitary word or its corresponding thought has become prevalent in it like that of gravitation; its varied phenomena—light, heat, electricity, chemism, liquids, gases, ethers—seem to lie around in its field quite disconnected, recalcitrant to any common ordering principle. It is true that the Diacosmos is the stage of separation in the movement of total Nature, still this separation has its law, its organization, yea its unity. This is what we are now specially seeking. For the Diacosmos with all its disintegrating tendencies is not chaos, even if some think that it is rapidly striding thitherward. Now we are going to apply to this whole sphere a category which has lately been formulated and applied to a portion of it only. This category is known as radio-activity, which starting as the unique property of a newly discovered element, radium, has extended its domain till we at present sometimes hear, rather indefinitely, that all Matter is radio-active or ray-emitting. It is to be observed that such a tendency of Matter to pulse forth energy is quite opposite to that of gravitation, the ruling power of the Cosmos, which Newton so completely enthroned almost at a single stroke of genius. A similar supreme lord over the scattered provinces of the Diacosmos has long been

needed and likewise sought for urgently, even if unconsciously for the most part. We say, then, that the dominating principle of the Diacosmos is radio-activity, as the dominating principle of the Cosmos is gravitation.

It is true that this radiating power has long been known, particularly in the case of Heat and Light, and more recently of Electricity. These are, accordingly, the radiants proper, and are to be put into a group by themselves—a diacosmical group. But that all the chemical elements—now set down at eighty in number in the most recent scientific book under my eye—originate in radio-activity, and are seemingly derived from one primordial radio-active element is a glimpse which the latest scientific discovery is giving us at this moment, rather uncertain and partially cloud-hidden still, but nevertheless very promising. At the other extreme of the diacosmical territory we shall find the fluids (as we classify them) in a state of incipient or potential radio-activity. So we may repeat that throughout the entire sweep of the Diacosmos radio-activity is the common principle which interrelates its diversified parts and expresses its deepest character.

It has been already indicated that radio-activity physically considered, must be the second or separative stage of Nature's total process. It is a form of Motion, the common diacosmical form, of which Heat, Light, and the rest are only varieties. Mo-

tion as primordial we have called the Separating, ever-dividing within and going beyond. Motion is now (diacosmically) radiation, yea self-radiation, a raying out and over; it has gotten inside of Matter, being no longer outside of it as in the Cosmos, which shows bodies moving by the external force of attraction, for instance. Radium with its radio-activity seems to be a particle of Matter transforming itself into Motion, which has thus quite appropriated and metamorphosed its old foe or primal counterpart. Nature as a whole is the second stage of the Pampsychosis grasped in its triune totality as God, Nature, Man. But Nature as derived must show the creative process of its source, namely the All-Self (Pampsychosis), for it cannot in the last instance give any account of its own cause or origin. So the Diacosmos we have to conceive as a new separation of the primordially separated Nature, and it gives a new manifestation of Motion, which we saw to be the first created fact of Nature, in its struggle with Matter, the second twin of Nature's earliest progeny, namely Motion and Matter. Diacosmical Motion, therefore, is revealed in radio-activity, the second grand activity of Nature.

If the Diacosmos is a member or a stage of the total organization of Nature, which is in turn but a stage of the still vaster All, we next come to ask about the organization of the Diacosmos itself, its own distinct process. This also must show itself

to be at bottom psychical in accord with the soul of its originator. The following scheme we shall set down as a kind of sign-post pointing out the future lines of the more detailed exposition.

First: the molecular or fluid Diacosmos, with its three leading forms—Liquids, Gases, Ether.

Second: the radiant Diacosmos, with radiation explicit in its three forms which we may name radiants—Heat, Light, Electricity.

Third: the elemental Diacosmos or Chemism, in which the physical universe is reduced to its ultimate elements (chemical). The element, however, will be still further analyzed into the atom, the ion, the electron.

Such is the end, at least the present end, of the Diacosmos, which, we may for the nonce suppose, starts with the common, ever-moving sensuous fluid called water, the typical liquid. Streaming through all these diverse diacosmical stages we are to see the fundamental principle of radio-activity under different shapes with its power of interlinking the many separate domains. But we are likewise to observe the inner self-returning movement in these three stages of the Diacosmos. Here we may specially note the act of Chemism, the third stage, as peculiarly significant: it goes back to the given material world and seeks to reduce it to its elements through and through; its historic starting-point might be deemed its first analysis of that typical liquid, water, which we have taken as the material beginning of the diacosmical cycle.

It may be said that science to-day is dominantly diacosmical, rather than cosmical or biological. Two hundred years ago it grappled with the mechanical side of the Cosmos in a mighty outburst of originality, whose greatest representative was doubtless Newton. Fifty years ago science became for a time overwhelmingly biological through the work of Darwin. But the crest of the scientific wave seems now to be rising and surging through the Diacosmos, whose most secret and remote nooks feel its pulsations. The infinitely small is pursued with a passion which only the spirit of the age could beget in the individual. The scientific mind of the present seems to be driving forward to its diacosmical fulfilment ere it start possibly on a new cycle of its development.

The scientist takes Nature as the given, with which to experiment, making it speak out its thought, yea its category. He accepts it at first hand, as the ultimate substance in which he works but which also works in him, transforming his very consciousness. Nature is the primordial separative stage of the universe, and imparts its character to the soul occupied with it sympathetically and continuously. Moreover we have found the Diacosmos to be the separative stage of this first separation—a fact which likewise stamps itself upon the spirit of the investigator of the present realm. So we have to think that the physicist himself gets to be diacosmical, he views all and the All

from his special sphere of life and labor. Hence it comes that he refuses to penetrate to the psychical source of his own world; that is the unknown and unknowable, the domain of mystery, beyond Nature, which is his spiritual home. Still further, he seems just now to be turning against the Cosmos with no little energy, and assailing its unitary principle of attraction which at least strives toward unifying all Matter through gravitation. But the diacosmical spirit is separative, analytic, radiative, seeking the atom and then dividing it again and again, as if in hot pursuit of zero. The eminent physicist, Le Bon, calls his own science anarchic, and, if we catch his spirit, rather glories in this character of it and seemingly of himself as scientist. Undoubtedly the time has a furious diacosmical strain which science must reflect, and which history must work out. Nations differ in this regard; politically Europe, with its system of separate states (Polyarchy) has a diacosmical similitude to the present science, more so, one may think, than the United States. Education shows a good deal of the same trend; the European University, which has been bodily transported to America, is in character as well as in science emphatically diacosmical, with its ever-deepening tendency toward specialization, and its weakness in universalizing and in the universal disciplines, though it still calls itself the university, the home of training to the universal. The

physicist (or the diacosmist), therefore, more than any other sort of man, is giving the spiritual time-beat to the present epoch; let him make hay while the sun shines, for his day will doubtless pass on like the rest, leaving a very considerable body of good science to the future.

We have already observed that the cosmical center of our planetary system is the sun as merely blind and heavy; the same body is the diacosmical center also, but as the luminous eye, or as radio-active. The solar character is indeed double: as a source of gravitation it attracts all to itself, then it turns about and repels all, even itself, radiating its own illumination far into the starry depths of the Cosmosphere, certainly beyond its own immediate system. The Sun, accordingly, acts both a cosmical and diacosmical part in one colossal manifestation; it is the synthesis of these two sides or stages of total Nature. It reveals the unity as well as the separation of the entire Heliosphere of which it is not only the spatial center but the producing cause. As far as it goes, it may be deemed the active Ego of its system, though it lacks as yet the completed self-return, of which it is the radiant prophecy. So we can hardly think the Sun as self-conscious, though on Nature's road thereto, flashing thitherward as if in a mighty aspiration. Nor can we conceive the sun be alive though the fostering nurse of all life on our planet.

It is evident that the Diacosmos taken by itself,

means universal dissolution, and that it has imparted to the scientific mind of to-day its own character. The cosmical attraction of Matter is reversed, its dissociation and disintegration are radiated back from our system into the Cosmosphere whence this energy originally came, but with an opposite tendency which was to coalesce in cohesion and to join in a systemic order. Whether the Cosmosphere itself is undergoing the same dissolution, cannot yet be told; we know not yet its conditions or limits against other Cosmospheres if there be such. But the likelihood is that it possesses certain powers of recuperation of which we have noticed a possible instance in the regenerative round of a stellar system (see preceding pp. 275-9). Indeed the All cannot be thought as perishing or perishable; if it be doing its undoing, it must also be undoing its doing, or negating its own negation.

It would seem, however, that total Nature, the all-inclusive, must show a limit, indicating that it (Nature) is not self-dependent, not self-generating, not completely self-determined, but has to go outside of itself for its final determination. Nature, then, reveals itself to be not the Totality, but a stage or a part of the one psychical, or rather the pampsychical, All. This limitation of itself it must show both in its entirety and in its parts; or, to repeat what has been already said, Nature manifests itself as dialectical, both as a whole

and in its particulars. Scientists say that the Planets start with a given motion from the Heliosphere; but the latter is also affirmed to have had an original push from the Cosmosphere, which in turn required a send-off, perchance the primordial one of total Nature. Now this Nature shows through and through, from largest to smallest, the original ejection or separation of itself from the universal Self (Pampsychosis); ultimately it comes not from itself but from another; it is not self-determined but outwardly determined. Such is the limit which Nature always manifests, externally and internally. Still just in this character we have to consider it as an inherent member or necessary stage of the universal Self.

The earliest elemental forms of Nature, Space and Time, the holders of the Cosmos so to speak, show, through the impossibility of limiting them within themselves, that they have their limit in their opposite, in that which limits itself within itself, namely Ego, Self. That is, the limit of Space and Time cannot be spatial, or temporal, they are always transcending it if once posited; in this sense they are often said to be infinite (limit-transcending). Certain is it also that they, as derived, are limited by their source externally, and subject internally to all sorts of limits. So Space and Time primordially reveal Nature's dualism, being both infinite and finite, either of which can be easily pointed out in them. The Diacosmos will

show this same character of Nature in a new and more intense way; as second stage of the physical totality it is divisive, and keeps dividing to infinity even Nature itself, so that the atom in one shape or other becomes fundamental in the diacosmical world.

The Diacosmos, in the present organization of Nature, lies between the mechanical or gravitational order (Cosmos) and the self-active, self-moving order of life (Biocosmos). We may conceive it as the great unloosening of the fixed physical world—it turns Cohesion into Dishesion, Gravitation into Degravitation, Composition (chemical) into Decomposition. It has its own distinctive process, which has been already indicated, but which we may here briefly repeat:

(I) The Diacosmos as molecular.

(II) The Diacosmos as radiant.

(III) The Diacosmos as elemental chemically or atomic.

The great diversity of the subject covers up with details the lines of its order; indeed the diacosmical act in itself is inclined to be repellent of any fixed organization, being such an unloosener of things. Still here, too, the process can be seen and unfolded.

CHAPTER FIRST.

THE MOLECULAR DIACOSMOS.

The conception of the molecule becomes now important. We have already had it in the cohesive Body, which is often said to be composed of molecules. But these are not yet really distinct or separated; they still cohere. This form of the molecule is cosmic rather than diacosmic. When, however, a force such as heat gets inside the cohesive Body and begins to drive it asunder, the molecules are separating, and become more and more individualized. At this point, accordingly, the Diacosmos distinctively starts in its first stage which may be called the molecular.

It is to be noted that the aforesaid separative force still remains outside the molecule though inside the body. From this point of view it acts mechanically and can be measured. But later we shall observe in Chemism the force getting inside the molecule, which is separated in its turn and is shown to be composed of atoms. Some distinguished chemists have held that the atom, too is divided by a new chemical energy; but that view must not detain us now. The best way is to distinguish the three different ways wherein Force, which is a form of Motion, works upon three different forms of Matter. (1) A particle of Matter is

a fragment of a body which has been broken; its separation is external and quantitative, and it maintains cohesion. (2) A molecule is an inner qualitative division which assails cohesion, and separates a body into its constituents (not into its elements). (3) An atom is an elemental division, and implies the separation of the molecule into its chemical elements.

So we distinguish the particle, the molecule and the atom; force drives the first one from the outside, but drives the two latter from the inside, and so these belong properly to the Diacosmos. The atom indeed goes back and atomizes both the particle and the molecule, for they also have their chemical character, which is indeed elemental.

In the cosmical realm we saw the body in a free unobstructed motion round the central Sun; or we may say that Motion controlled Matter in the sweep of the planets. But each molecule of the planetary body was subjected to the might of cohesion. Now in the diacosmical realm the tyrannous power of cohesion is broken, and the molecule is liberated from what may be deemed its servitude by a stronger counteractive energy. Its forceful liberator breaks its chains and gives to it a new individuality which is soon seen asserting itself, and transcending its limits. Particularly the molecules of a gas show an aggressive individuality by their expansion. A kind of liberation we may well see in this molecular society, as it opens

its career in the Diacosmos, which thus becomes relatively a world of free molecules, getting more and more emancipated from the cosmical servitude of cohesion.

The result is a decided transformation of material body, both externally and internally. This metamorphosis is usually deemed threefold—solid, liquid, gaseous. Nature has furnished instances in the so-called elements—earth, water, air. Moreover one of these elements, the liquid, manifests all three forms through molecular changes, becoming ice, water, steam. This is the work of heat, through which water as having a neutral character by nature, is easily influenced. Water with its easy-going molecules, quite indifferent to one another, and uncohesive at ordinary temperatures, is the least refractory of forms of Matter. Air, on the contrary, by strong pressure can be brought to be a liquid, perchance a solid. A metamorphic power thus lies in the molecule, it is the Proteus of the Diacosmos.

Motion, the Separating with which Nature starts in the Cosmos, at first works upon corporeal Matter externally without assailing its cohesive individuality. But now Motion is seen at work within the material body and drives it asunder internally, constitutionally we may say, transforming it and endowing it with new characteristics. Ice and steam are the same substance but show very different forms and different traits.

But what drives these fluids asunder? What gets between their molecules pushing them apart and raying them out in opposition to inertia, cohesion and gravitation? It has been called simply force or energy. Still, we ask, what kind of force? A form of that radio-activity which must be considered as the fundamental property of the Diacosmos. We learn that all Matter is radio-active and has the tendency to emanate. The new element radium has introduced this idea of the material world. Motion, the Separating, has gotten inside of body and is rending it and exploding it, even dematerializing it, as the claim is now sometimes made.

We have called this sphere the Molecular Diacosmos, looking at it under one aspect. From another point of view we may regard it as the fluid world, its category being now fluidity. Such a property naturally springs from the foregoing separated or uncohesive molecules, which even when massed are quite outside of one another and move easily asunder. It should be here noted that we make a distinction between fluid and liquid, though ordinarily they have quite the same meaning. Fluid we shall employ as the general term for the entire sphere, while liquid is a particular form or stage of it. Fluidity, accordingly, means hardly more than the simple direct dishesion of matter, which is supposed to have its limit at the molecule. There is no attempt in the present sphere to get

back of this molecular separation, and to find what produced it; we take it as it is immediately before us, or as it is supposed to be in the case of ether. Later (in the radiants) we shall delve into the grounds of such a state of Matter.

Here, then, we are to forecast in brief outline the movement of the molecular or fluid Diacosmos, which will show the following three stages:

(I) The Fluid in its molecular indifference, or the Liquid, whose common example is water.

(II) The Fluid in its molecular separation, or the expansion of the Gas, whose common example is the air, with its limited expansibility.

(III) The Fluid as universal, or conjecturally so —the Ether, with its supposed absolute expansibility.

The three sections in which the Fluid as a whole is treated will be named simply the Liquid, the Gas, the Ether. It is to be noticed that they show a process together: the unseparated (indifferent), then the separated or self-expansive as limited and particular, finally the self-expansive made universal (in theory) and hence self-undoing, wherein lies the conception of a return to the Liquid, which is not self-expansive. Such is, in abstract outline, the movement of the Fluid, which the following details will serve to illustrate more concretely.

I.

The Liquid.

As already indicated, the Liquid is but one kind of Fluid, under which general term we place also the Gas and the Ether. All Fluids have the common characteristic of molecular mobility, consequent upon a loosening of cohesion. The fluid molecules, however, persist in the present stage of the Diacosmos; not till we come to Chemism are they assailed and dissolved into their atomic elements. In the solid body there is what may be called a cohesive individuality, which can indeed be separated from the outside as when a bar of iron is broken in two. But a Fluid cannot be broken in that way; its molecules are already separated in themselves and so can be put together again just as they were by mere contact. In the structure of the Fluid, therefore, the molecules are more or less indifferent to one another; each has gotten outside of the other and stays there; consequently the individuality of the molecule is emphasized rather than that of the total body; the molecule now resists cohesion and asserts itself. This shows distinctly its separative, diacosmical character. Dishesion we may designate this tendency in contrast with cohesion, which is a might over the individual molecules forcing them tightly together; a tyrant perchance we may call this cohesion, sup-

pressing molecular independence which at present seems the aspiration of Matter as of Man.

That which differentiates the special Liquid from the next Fluid is its non-elasticity, its unexpansibility. Compared to the Gas for instance, the liquid molecule cannot be lessened or increased, compressed or expanded. It asserts stolidly its own individuality in both directions. It persists stoutly in remaining just what it is against all external power. Moreover the liquid molecule, though always in contact, is not very sociable with its neighbors, who are, however, just like it. In fact liquidity and likewise all fluidity is a kind of dissociation of Matter, a loosening of its bonds. From this point of view the Liquid as a whole is very penetrable; its molecules are so indifferent that they let anything come between them mechanically. But individually they are altogether impenetrable. A splinter of wood thrust into a cup of water never gets inside an aqueous molecule but it very easily passes outside, for this molecule cares nothing for its next neighbor. Very different is the furious resistance offered to the intruder by the associated (or cohesive) molecules of a piece of iron. At the same time if the solid be broken, the structure itself is destroyed along the line of cleavage, and will not unite again; the very molecules seem broken in their power of association. But the Liquid has no such power, its molecules are inclined to stand alone, they are individuated.

To be sure Liquids differ much in their molecular mobility, as well as in their inter-molecular character. Some Liquids through their viscosity approach a solid; a jelly, for instance, will retain its corporeal form. But in general the molecular indifference of the Liquid is such that it requires a vessel or some holder to keep it together; otherwise the molecules will run away from one another, each seeking the nearest point in line with the center of the earth. Each molecule thus asserts itself a complete body by itself, with its own particular gravity. We may deem it a kind of ultimate element in this fluid stage of the Diacosmos, not a chemical element, of course. It is nearly irreducible by pressure, though not quite, as may be seen in Oersted's table of liquid compressibility; alcoholic ether, for instance, is twice as compressible as water, while the liquid metal mercury is but one-thirteenth. Each Liquid has, therefore, its own degree of resistance to external pressure; but it at once resumes its former volume when the pressure is removed. The Liquid can be made to yield just a little, but it returns to itself as soon as it can, re-asserting itself we may say.

Water we may take as the typical Liquid, whose character is deserving of our best study. Chemically it is known to be composed of two gases, hydrogen and oxygen; but nobody could tell anything of its form or nature from its composition. It is the most universal of Liquids and may be

deemed the base of nearly all of them, though it is not a chemically elemental Liquid like mercury. Still it has been long called an element, one of Nature's own, being endowed with a unique individuality. In antiquity it inspired the earliest philosopher, Milesian Thales, who regarded it as the principle of all things, or as the essence of being. Through its very indifference it can and does become many things, especially entering into life. It is the unformed which is to be formed; it takes shape or body from the outside, through its holder; still it seeks form and clings to the same, for instance in capillarity. That water wets an object has a meaning: it clings to something which it has not but strives for, and the drop falls down only when it has another drop for its support. Thus water shows itself indifferent to itself, being just the medium of indifference, which takes everything's part but its own. Neutral in itself and to itself it can be without bias, and enter into the special works of Nature impartially, we might almost say sympathetically. Strictly it has no taste, no smell, no color, no shape, no cohesion, no resistance if taken aright; yet it easily becomes a medium for all these properties. As the first substance of the Diacosmos, it is the implicit potential stage, the possibility of future shapes, bearing in its bosom the seeds of things; it is passive till its molecule is reached, when there is strong self-assertion. If a board strikes on its flat side the

surface of water, it assails many molecules at once and meets a common resistance; but a little push will easily separate the same molecules, as they are not really combined.

Undoubtedly water is negative to cohesion, and will dissolve many bodies, holding them in solution, but not disturbing them chemically, though it often gives the chemical process a good chance to act. Enormous is the quantity of this Liquid on our planet, being its chief medium of exchange; water is also a mediator between earth and sky, as well as between lands. To our terrestrial temperature water is peculiarly adjusted, to heat and cold; above the limit it loses its liquidity and becomes vapor, below the limit it shows the same loss but becomes solid as ice. Water probably originated when the earth had cooled off to its present very limited range of temperature, and helped to bring forth its life. But the most striking adjustment is that water contracts from the boiling point till 39 degrees Fahrenheit, then with the increasing cold it expands till it becomes ice, which is lighter than its own liquid. Thus from a certain point of temperature it expands both through heat and through cold; water shows a peculiar control over heat and cold, making both of them contradict themselves; it causes heat to contract and then to expand its molecules (from below upward), or it causes cold to do the same thing (from above downward). This peculiar exception to an other-

wise general law of Nature is often cited as an instance of providential design, since ice, being lighter than water, protects it in winter and prevents lakes and streams from freezing to the bottom and thus becoming a solid mass of ice. At any rate it shows the strong endowment of the aqueous molecule that it contracts or expands with heat according to its own law, and not according to the general law of heat. A few other substances show the same exception, notably the metal bismuth. What we have called self-assertion of the molecule of water with its defiance of the old law, may be regarded as the overture of the Diacosmos, which we have already seen running counter to the previous mechanical principles of inertia, of cohesion, of gravitation. Still under these seeming violations we are to find the new order which also has its law.

Accordingly we have first to investigate the diacosmical process of the Liquid, properly the first manifestation of the present sphere. Here we shall find three significant stages which we may formulate as follows:

(I) Molecular Attraction of the Liquid—different from, and in some respects opposite to, the previous cosmical attraction.

(II) Molecular Resistance (Repulsion) of the Liquid—which has also its peculiar ways of manifestation.

(III) Molecular Gravitation of the Liquid—

wherein it is seen in its terrestrial relation. This last stage overcomes the separation of the second stage (Resistance) and goes back to the first (Attraction) which it underlies. That is, all molecular diremption is finally dominated and ordered by the earth's power.

The reader will note that these three categories of the liquid Diacosmos show a decided similitude to those given generally to Matter (see preceding pp. 92-101), of which we are now to consider a new particular manifestation.

I. Molecular Attraction of the Liquid. The primal fact of the Liquid is its tendency to separate into molecules, each of which has a certain degree of independence. Each may be conceived as a kind of pellet, exceedingly small, with its own center and its own individuality. It holds itself together mightily, but turns away from all the rest of its kind; this gives its divisive character—molecular separation, and also molecular mobilility, for each pellet seems to roll upon and around the contiguous pellets without entering them. But as there is this outer separation and even repulsion of one from the other, so on the other hand each molecule is bound into unity by an inner attraction which makes it almost impervious to any external impress from one of its kind. We might say that the outer *inter*-molecular cohesion of the solid has been transferred to the inner *intra*-molecular cohesion of the Liquid, and that we

have passed over the bridge from the Cosmos to the Diacosmos. Thus we begin to think that the molecule taken by itself is a system of attraction—a thought which will have a future. Now this attraction of the liquid molecule within itself is the immediate fact which is first to be considered. Such an attraction seems to show a kind of voluntary molecular activity; the molecule spheres itself, it diffuses itself freely, it raises itself up along a solid of its own inner bent. It is to be noted again that these three phases of molecular attraction are in opposition to gravitation, and thus diacosmical.

1. *Spherular Attraction.* By this is meant the tendency of a free Liquid like water to take the form of a spherule in a small mass. The rain drop and the dewdrop ball themselves of their own force; they are much larger than a molecule of water, but they reveal its existence and its power, as well as a certain limit placed upon it. The metallic liquid, mercury, shows the same trait more decisively with its divisibility into smaller and smaller spherules. Molten lead poured through a seive from the top of a tower can be made to take various spherical sizes while falling to the ground. Free motion imparts individuality, and the round world gives of its rotundity. The planets circling freely through space take the same form. The molecule is, accordingly, conceived generally to be spherical, having its own center of attraction.

2. *Diffusion of Liquids.* This is twofold and starts with separation, but shows it overcome. Two different liquids—for instance a solution of copper sulphate and water—will at first assume two different layers in a vessel one being heavier than the other. But they at once begin to intermingle and will soon form a uniform Liquid in opposition to gravitation, the heavier one rising and the lighter one falling. This is essentially the same as diosmose in animal and vegetable life. Water as the molecular medium performs its function of mediating the side which has something, with the other which has not. This is owing to the free movement of the individual molecules. There are, however, liquids which do not mingle, whose molecules draw a line of permanent division between the two hostile sides, as do oil and water. In this case the separation remains. But both the antagonists will show a common trait in the following.

3. *Capillary Attraction.* When a Liquid is placed in contact with a solid, the molecules of the liquid rise up the side of the solid and adhere to it for a perceptible distance above the surface of the liquid. If a tube be used with a very small bore, the rise in it is still greater. We behold here again a kind of cohesion between solid and liquid in opposition to gravity. But when the liquid has to adhere to itself, it drops back into obedience to gravity; we behold the molecules of the liquid seeking the molecules of the solid, but indifferent to its own

molecules. It strives to separate the cohesion of the solid and to mediate it with something else, the liquid and especially water being the great go-betweens of Nature. Capillarity shows that the liquid molecules have a greater attraction for the solid than for one another. Still they have also in themselves as individuals a decided resistance to the solid.

II. MOLECULAR RESISTANCE OF LIQUIDS. We have noted the molecular attraction of the Liquid for the solid; similar attraction was inside the molecule. Equally emphatic is the resistance of liquid molecules under certain conditions. The tendency to sphericity may be interpreted as an inner gathering of force for any emergency. The formation of the globule hints a process of individuation; it thus forms itself, makes a body, which the solid cannot do. The impact upon the Liquid as a mass reveals its power of resistance, its strong self-assertion. It seems to have the ability to unite all its separate molecules against a sudden assault, as when a flat surface smites the water. Here again rises a phase of the impact of bodies which has its place also in the Cosmos (see preceding pp. 188-215). And again we shall observe essentially the same movement: Impact by pressure, Impact transmitted, Impact as mechanical or multiplied by mechanical devices. All this now pertains to Liquids.

1. *Pressure.* When a Liquid such as water is

subjected to pressure in a strong vessel, it is found to be quite unyielding. Water was thought to be incompressible till Oersted, in 1823, found that the weight of one atmosphere would reduce its volume one part in twenty thousand. The pressure being removed, each molecule would resume its former size, and was as indifferent to the rest as before. The pressure, however, made them all resist in common, though it did not unite them in a permanent bond, which would indeed destroy their liquidity. We have, therefore, to conceive each molecule fighting for itself against the common foe without much mutuality. Being restrained from the outside, it will associate with its kind a little, just enough to produce resistance of the Liquid under pressure, which can be measured. Such is the first or immediate phase of molecular resistance of the Liquid.

2. *Transmission of Pressure.* Though the molecules of the Liquid are nearly incompressible, they have a remarkable power of conveying pressure, of passing it on to the next till the end of the line. Here is the field of Pascal's law, whose statement is that pressure upon a Liquid is transmitted in all directions, and acts at right angles to the surface of the containing vessel—up, down, right, left. Thus the molecules form lines of transmission of pressure running through the Liquid every way to the surfaces exposed to this Liquid. Lateral pressure is shown by the interesting contrivance called

Barker's Mill. If the pressure of the Liquid is relieved on the one side by an aperture, it pushes in the opposite direction and will drive a wheel, whirligig, etc. This principle of pressure is independent of the shape of the containing vessel; the molecule will always receive and transmit the impact to what lies next. It follows from the preceding law that upward pressure works in the same way as downward pressure. From every molecule springs an all-sided resistance to any restraint of its free liquidity.

3. *Pressure Mechanically Multiplied.* Pressure cannot only be transmitted along every line of molecules in every direction, but it can be indefinitely multiplied. It has been noticed that a small column of water balances a large one when the two are connected, as in the spout and body of a coffee-pot. If pressure be exerted upon a small column, this will exert a force upon the large column great in proportion to its size. A line of molecules will thus impart and repeat its own force to many lines of molecules, each of which gets not merely its share but the entire pressure. It gives its all to each. Hence the surprising power exerted by a small column of water, say 30 feet high (as in Pascal's famous experiment) which will burst a stout cask into which it is poured.

Thus molecular resistance to pressure may be made to come back to itself by transmitting it through other molecules, with a vast increase of

power. A resistance to a pressure of ten pounds can be converted into a resistance to a pressure of ten thousand pounds by a hydraulic machine. Thus the pressure of ten pounds will equilibrate itself a thousand fold through a mechanical device which is analogous to the lever. There is the downward pressure (P) which is directed through a small column of water into a large column which is pushed upward against the resisting body or weight (W) which is to be moved (see preceding pp. 201-9). Each molecule may be deemed a kind of fulcrum (F) which turns the first pressure (P) against the second pressure (W), or we may say which converts the first resistance into the second with a great multiplication of force. This multiplication is the peculiarity of the hydraulic machine; the simple lever can change time and space into power; but a molecule directly imparts its received power as a whole to the adjoining molecules; one unit of energy in thus converted into ten or a thousand through molecular pressure.

Such, then, is molecular resistance received, transmitted, and multiplied by a machine. The free individual molecule of the Diacosmos in this way shows itself to possess a different character from the unfree cohesive molecule of the Cosmos, which has seemingly no such power of self-assertion and self-impartation. But underneath this somewhat independent molecular action lies a deeper might which determines it, namely, that of

the earth, for the molecules also must at last gravitate to the common center.

III. Molecular Gravitation of Liquids. The Molecules of the Liquid have weight and obey the law of gravitation; they arrange themselves in a vertical line toward the middle of the earth. The solid with its cohesive molecules has its weight concentrated in one point called its center of gravity. But the liquid molecules through their lack of cohesion, unless confined somehow, cannot be said to have such a common central point as has the solid, but each molecule has its own center and obeys the law of gravitation for itself, rolling toward the same by the shortest way. And in a vertical line of liquid molecules the lowest one has to bear the weight of all above it, as we have observed in their molecular pressure. But in the solid the molecules do not independently transmit pressure, but rather as one body which conveys its power as a whole, and receives resistance as a whole till broken.

The Liquid then manifests molecular gravitation, which assumes first its immediate form of equilibrium; then this equilibrium is assailed and undulation of the Liquid takes place with return to equilibrium through gravitation; finally this molecular gravitation of the Liquid (usually water) is made the unit of measure by which the gravitative character (weight) of all substances is measured and compared.

1. *Equilibrium of Liquids.* In a liquid mass the lines of molecules assume a vertical direction toward the earth's center, while the surface of the same mass at rest is horizontal to these molecular lines, one being at right angles to the other. If the surface is disturbed it seeks to regain its equidistance from the earth's center, which is called its level or equilibrium, and is the result of gravitation. That is, when the surface of a Liquid makes a right angle with the earth's radius, it is equilibrated by gravitation. This holds, however, only for relatively small distances, large bodies of water show a curved surface drawn by the earth's radius, in accord with gravitation; the terrestrial center may in a sense be said to radiate the equilibrium of Liquids on the terrestrial surface.

2. *Undulation of Liquids.* We must next see the equilibrium of the Liquid broken up by some outside blow, whereby it enters upon its separative phase which shows it in a new character. The assault upon the Liquid calls forth a response from it which makes explicit certain traits quite implicit in its previous quiescent state of equilibrium—traits which gather about one main fact, that of undulation, which is a kind of separation ever repeating itself in the mobile molecules of the fluid.

The conception of the wave has come to play a great part in the Diacosmos, as we shall often see later. Its starting-point may be deemed the undulation of the liquid, especially of the typical

liquid, water. The wave is a disturbance of the equilibrium of its molecules; particularly the surface is broken up from its level which results from its settled adjustment through gravitation. The result is a peculiar balancing or tetering of these liquid molecules, which have the capacity to convey energy, though they do not convey themselves unless propelled by an outside power. If in the middle of a quiet pool a pebble be cast, we observe a series of concentric wavelets moving outward to the shore. Furthermore, each wavelet has in itself an up-and-down movement, or oscillation, which continues after the first crest has passed, but grows less and less till it gradually settles back into equilibrium. This undulating oscillation becomes a kind of vibratory molecule in large, which communicates the motion which it has received without moving forward itself. If we scatter bits of wood over the surface of the pool, we shall see them bobbing up and down mainly in the same spot, and not being borne on the crest to the shore.

The liquid wave, therefore, moves within itself in a kind of rotation upon its own axis, this is called strictly its vibration. At the same time it reproduces itself, its own form and movement in the adjacent liquid molecules; this is its communication of motion and of force, which passes on outward to the edge of the pool. The third fact is that this line of motion radiating from the center

of disturbance in every direction cuts these vibrating waves across at right angles, that is transversely; the transmitted motion is transverse to the wave in its tetering or oscillation. There are two motions here which must not be confused: the rotatory and the imparted; the imparted motions are ordinarily called transverse vibrations and are separated spatially and temporally.

This fact becomes important since the same kind of Motion is supposed to be that of the Ether, which herein resembles the Liquid. Heat, Light, and Electricity are or perchance produce transverse vibrations in the Ether; that is, a transitional motion or force radiates outward though generating etheric undulations. The air-wave is different. The wave-length is measured from crest to crest or from trough to trough (really wave-breadth), and may be rapid or slow according to the radial force.

It is evident that in the undulation we see the Liquid repeating what has already been observed in the solid. At a number of points the up-and-down of the wave suggests the oscillating Body (see preceding p. 226); it is a fluid pendulum vibrating in a fluid and reproducing itself vibrating. But the oscillation of the free mobile material is supplemented by rotation, even by the spherical form which rotates and easily throws off other liquid spheres which also undulate. Such a movement

of the sea-wave is said to have been first set forth by Gerstner, who propounded that "its particles move in circular orbits" (at the beginning of the last century). This fruitful idea must be carried out to the conception of self-propagation through rotation, many instances of which we have seen in the motions of the Cosmos (see account of the Rotating Body as solid on preceding pp. 233-42). It would seem, then, that in the undulating process of the Liquid we behold again rotation, radiation, reproduction of rotating bodies with some sort of orbital movement. If this be so (for the subject has by no means yet been developed by physicists) the action of the wave of the pond is a limited sort of world-making, as this has been already unfolded in the Systemic Cosmos. Each molecule may be deemed a little planet in its liquid state throwing off satellites. Later we shall see that the physical science of today is inclined to regard the atom as a small Solar System with its revolving orbs. In general the struggle between Gravitation and Rotation takes a new form in the undulation of the Liquid.

Undulation has the tendency to return to equilibrium, to the level surface under the influence of gravitation. Besides there is the so-called surface tension of the Liquid which has its strain upon the agitated waves. But the molecules of a Liquid are not elastic and transmit motion directly in wave-lines. Every undulation strives to regain the line of gravity with the earth's center. The

wave-movement proceeds transversely, though always being pulled downward by the earth's attraction. Undulation, accordingly, starts with a disturbance of the equilibrium of a Liquid, proceeds to impart this disturbance in wave-forms, and ends in a return to equilibrium through gravitation. Liquid molecules, are, therefore, heavy, as are all molecules; how can they be weighed? Too small for a pair of scales they must somehow be measured.

3. *Specific Gravity.* The definition of a famous physicist may be first set down. "The specific gravity of a body is the ratio of its density to that of some standard substance, generally water" (Clerk-Maxwell on Heat). According to this conception it is the measure of the densities of material bodies; one of these bodies as standard measures all the rest. This standard usually is distilled water at its densest (heaviest) temperature (39.2 degrees Fahrenheit or 4 degrees Centigrade). Or Specific Gravity tells the comparative weights of the same volume (say a cubic inch) of different substances. The weight of a cubic inch of water being taken as the measurer (our liquid yardstick), platinum weighs 22 + times as much, lead 11.35 times as much (platinum compared to lead is nearly twice as heavy), amber 1.07 (barely sinking in water); mercury, which is liquid, weighs 13.6 times as much as water, the standard liquid. Thus bodies filling the same space are found to

have a scale of very different weights or degrees of gravity.

Specific Gravity is essentially a measurement of molecular attraction, the molecules being deemed of the same volume. A molecule of platinum gravitates earthward with much greater force than a molecule of lead; the measurer water is to give the exact quantum of this force (twice as great according to the ordinary tables of Specific Gravities). A metal weighed in water displaces just its own bulk, and is found to weigh exactly so much the less. A metal weighed in air may be directly compared in weight with another metal so weighed. But there can be in this way no measurement of their relative molecular weights, which require the third as basis of comparison. Immediate weight of bulk as bulk is cosmical, specific weight is diacosmical, since the molecule is weighed and compared.

The Specific Gravity of gold is 19+ that of silver 10+ an alloy of equal parts of the two would be nearly 15 (times the same volume of water). It is evident that Specific Gravity can be made the test of the purity of metal. This was the principle discovered by Archimedes, who was required (according to the story) by the king of Syracuse to find out whether the royal crown of gold had been alloyed by the goldsmith who made it.

Here we conclude the third stage of the Liquid, which we call its Molecular Gravitation, whose

main phases we have seen to be Equilibrium, Undulation, and Specific Gravity. Moreover, the first part of the Molecular or Fluid Diacosmos has come to an end.

II.

The Gas.

We are compelled to use the word *gas* in its general sense, including vapor and air as well as its own special form. It is a fluid of which probably the most characteristic property is its elasticity or expansibility. On the whole a Gas may be called an elastic Fluid. It differs primarily from the Liquid through its molecular dilatation; it is separative in its molecularity which the Liquid is not, or is but slightly; water when it becomes really expanded and expansible turns into a gas or vapor; in its ordinary state its molecules resist both compression and expansion, while the Gas herein is quite the reverse. The latter seeks to get beyond itself, pushing out its bounds more and more till the last degree of tenuity, as in the case of atmospheric air.

So it comes that the Gas shows the second or separative stage in the total process of fluidity as here conceived. It is not indifferent to itself like water, but is by nature self-repellent; it thus must be regarded as in a state of perpetual separation from itself. Still it is heavy and at last yields to gravitation, or is properly yielding all the time;

hence it belongs to the first or fluid stage of the Diacosmos. Through its expansibility the Gas manifests its opposition to the cosmical attraction of the earth, which, however, finally overcomes it after many a rebound extending in the case of the atmosphere far upward into space. The Gas, accordingly, shows in its native activity the unceasing fight between Diacosmos and Cosmos.

The Gas has properly no surface since this is perpetually being broken up through the ever-struggling gaseous expansibility. The surface of the Liquid comes to equilibrium and rest through obedience to gravitation; the Gas is not so submissive, but repels such attraction as long as it can, to the last moment, we may say. Volume the Gas cannot be said in strictness to have, as its inherent tendency is to break across the fixed limit put upon it in any way; though rarified more and more it strives to spread out more and more. This is made visible by the expansion of a bladder filled with Gas and placed under the receiver of an air-pump; the completer the vacuum, the greater the distension. Still the other side must not be left out: the Gas, though essentially without fixed surface or volume, and always aspiring heavenward, has notwithstanding weight, is continually being drawn the other way, namely earthward. Such is its inner diacosmical dualism manifested in the salient quality of the Gas.

It should also be noted that the Gas has no

shape of its own like the solid, and does not take the shape of the containing vessel like the liquid; it can be only brought to shape by a complete enclosure which produces pressure against its ever-expanding molecules. Like the liquid it may be called formless, but it is something more; it actively resists form (which the true liquid does not), it resents limitation and will burst its restrainer if it can. The Gas shows itself as imprisoned when condemned to be put into a form, and aspires for liberation. This is again the result of that deepest trait of Gas, expansibility.

There is some question about the ground or source of gaseous expansibility. We may deem the primal tension to be molecular as well as intermolecular; it seems to reside in the molecules as well as between the molecules. And here we must note a difficulty in construing for thought this entire realm of Gases: can the idea of the molecule be properly applied to them? They form so many and such extended mixtures that their character seems to be miscible rather than chemically composible and decomposible, nor do they seem much inclined to hold foreign matters in solution, as do liquids, and especially water. Gases mix externally rather than unite internally by affinity; this lies also, we have to think, in their rebounding, recalcitrant character already described. But the unit or particle of such a mixture—can it be rightly called a molecule which is usually deemed a chem-

ically united compound of different atoms, as in the case of water? If so, its common meaning must be widened.

The number of Gases recounted in chemistry is somewhat formidable. There is a group of elemental Gases well known: oxygen, hydrogen, nitrogen, chlorine. A much obscurer group has been quite recently discovered: argon, neon, xenon, crypton, and the gaseous emanation helium. These new gases seem to be the extreme examples of the gaseous character; they only mix and persistently refuse to form a chemical union with any other Gas or substance whatsoever. In the language of the chemist, they are inert of combination, and as far as yet tested, they cannot be made to reveal, by heat, electricity or other physical compulsion, any lurking affinity for the rest of the elements or their compounds. The isolation of these Gases is thus unique and manifests in its last potence the resilient, refractory trait of the gaseous character.

As there is a typical Liquid, water, so there is a typical Gas or elastic fluid, namely atmospheric air. Anciently this was likewise deemed an element, one of the famous four, and was made a principle of philosophy apparently by the old Greek philosopher, Anaximander. Though we shall find it to be a mixture of elements and sometimes of compounds in the gaseous form, it has its own distinct individuality, as well as its separate,

very important place in Nature. So significant of the whole domain is it that the Gas is often named an aeriform fluid. So we shall give some brief considerations to air by itself, as the one gaseous character after which the rest more or less closely are patterned. It represents the Gas not only by its expansive nature, but it is also internally dual, being itself a Gas made up of two Gases (and sometimes more) not combined, but separate, as we shall see later. Thus it emphatically shows the separation of the Gas as the second stage of the total sphere of the fluid Diacosmos.

Air, then, is not a chemical compound but a mixture of two Gases, chiefly oxygen and nitrogen—by weight 23 parts of the first to 77 of the second, by volume nearly in the relation of one-fifth oxygen to four-fifths nitrogen. The general relation of these two elemental gases is that oxygen is a very active principle, an assailant of all bodies, a consumer, a destroyer; but that nitrogen is more a passive principle, a restrainer, a damper upon the furious energy of its ever-present associate, though antagonist. Foes to each other they may be regarded, yet twinned together in the smallest particle of air; significant it is that man and all animate Nature must inhale with every breath such a war of two opposing elements that he may live. In pure oxygen he would burn up inwardly. In the air are often found other assailing gases, also other inert elements besides nitro-

gen, as argon; so our air in its very constitution, is the seat of a continuous elemental struggle, which we take up in the breath of life. Man, therefore, breathes conflict and lives by it literally.

It is evident that air, compared to water is separative, dual, self-divided and even self-assailing. Water is a chemical compound with strong affinity between its constituents; no such elemental antagonism like that of air does it manifest, rather the opposite. Both water and air may be taken as pairs, which are in their ways sexed, yea are married; but the two of water are happily united in love, while the two of air are indeed interlocked in a kind of wedlock, yet in an everlasting quarrel. Water is unquestionably hostile to cohesion of body, and dissolves the same if it can; still it holds the dissolved particles hospitably, or mechanically we say, in solution, quite unchanged. Air is more vicious in its assault upon body, seeking to decompose it, even to burn it up. Air is a slow fire, it not only feeds combustion but is combustion, and can be made to show its fiery temper. Well known is the experiment of condensing air till it becomes a spark which sets on fire a piece of punk. The act of compressing air concentrates its expansive, naturally dilated nature into a point which becomes suddenly luminous in a flash; the inner character of air reveals itself for a moment in that scintilla. Light and Heat lurk in its bosom, as well as the source of fire, that Promethean spark

which was fabled to have been stolen from heaven. Air may become fire, and fire returns to air with the products of its combustion; so we note here a small cycle of elemental energies.

Oxygen is common to both water and air; it may be deemed their interlinking Gas, though it has such a different character in the two fluids. Chemically united with hydrogen, its negative might becomes quite neutralized and forms what we may call the neutral liquid, water, whose every molecule is so happy in its home or so complete in itself that it cares little or nothing for its molecular neighbor who, however, is just like it. Very different is the conduct of oxygen when tied mechanically to nitrogen, whose inert passive character it detests but cannot get rid of. No divorce, however, is allowed in that aerial domain; the couple have to dwell together in the smallest tenement, namely in the molecule or particle of which the whole circumambient atmosphere is built many miles high.

Air we may designate as heterogeneous both in composition and character, while water is homogeneous. Air like water is a medium and a fluid; it has properly no taste, no smell (though the bearer of all smells), no visible body, even if it be heavy. Its mediating power is subtler than that of water and harder to get hold of; the marine ship has long been, but the aerial ship has not yet arrived, though it seems to be coming in sight just

now. Air also has its waves which convey sound and which have a special sense in man and animal for their right reception; air waves probably evolved the ear in the course of the æons.

It is also noteworthy that these two typical Fluids, water and air, hint a kind of universality in their terrestrial relations; both of them form vast circumambient oceans (even if limited) which embrace our earth and feed all life. It has been supposed that man arose in and from the water, and passed thence to his finer habitation in the air, from which he is to remove to his yet more etherial future home. In such a case the human being is still going through his fluid evolution, living now mainly in its second stage, the air, having risen out of his aqueous abode, but not having yet attained his etherial dwelling-place.

Dropping these remote speculations we come to the problem of organizing this present sphere, that of the Gas, which has been developed by specialists in no little detail, whereof only small notice can here be taken. In general outline, however, the process of the Gas will be quite similar to that of the Liquid; both Fluids have a common movement and character in the molecule, though this takes a different form in each. The Gas, accordingly, shows first its immediate molecular character; then its molecular resistance, inner and outer, or its stage of separation; finally its molecular gravitation, or its return out of resistance

and expansion to a unity with the earth's attraction.

I. Molecular Character of Gases. The molecule of the Gas through its expansibility has no fixed limit, such as we have seen in the molecule of water, but is endowed with a kind of radiation (a phase of the diacosmical radio-activity). It drives outward toward infinity, not only formless but form-destroying both in itself and in other bodies. The air for instance is a corroder, assailing the bound of solids, and gnawing at it slowly and secretly but effectively with the years; air may be deemed the tooth of Time, which tears to pieces the finite world. It is the bitter if hidden foe of material finitude. Water dissolves and retains, air dissolves and carries off—in which act we can often detect it by one of our senses, that of smell. Here may be mentioned that recent science has located a part of this destructive power of air (and seemingly of other Gases) in living things, micro-organisms, which for instance assail an open wound and are destroyed by the so-called antiseptic treatment. In general, however, we have to consider the Gas in this aspect as the double separator, separating perpetually from itself (expansible) and separating corporeal existence. Such is its diacosmical character; it countervails inertia, cohesion, gravitation. On the other hand we should not fail to note that just this negative power is its power of purification; it assails the de-

structive agencies ever working in the physical world, it is also the purifier of Nature's finitude, or at least of a part of it; in fine it is a negation of a negative. Nor should the significant trait be forgotten that air has the gift of self-purification; curative of others it must be able to cure itself; it, too, is material, finite, often inoculated with disease, which it has to heal. What does it do with its varied contents? That secret has yet to be largely told; but it shows itself able to get rid of its foreign ingredients gradually and to return to its native composite of oxygen and hydrogen. Such is the round which it is forever making.

1. *Sphèrules.* Though the periphery of the gaseous molecule is always changing, still it must be conceived as an ever-enlarging spherule. Herein is its basic difference from the liquid molecule which holds so rigidly to its limits in space, being nearly incompressible and inexpansible. From this point of view the gaseous molecule is decentral or radial; it has a tension or motion outwards. Here lies the chief ground for the so-called kinetic theory of Gases which has often been assailed and often defended on inadequate grounds. The simplest (and seemingly most gratuitous) statement of this theory is that of Tait: "the particles dart about in all directions," while Clerk-Maxwell seems to invoke demons to account for such molecular capers (if he is not joking). At any rate we have already seen rotatory spheres throwing off a radial

energy in the Cosmos, and the spherule might do the same, with a result if not the same, yet not dissimilar.

2. *Diffusion of Gases.* We have already noticed the diffusion of Liquids within certain limits; still more general and emphatic is the diffusion of Gases. These, through their expansibility, come together and mingle in all parts of the containing vessel. This was shown in the experiment of Berthollet with two hollow globes, the upper of which was filled with the lightest Gas, hydrogen, and the lower with carbonic acid Gas, 22 times heavier. Through stop-cocks the Gases were allowed to mingle, and after a time the two globes were found to have the same mixture of both Gases. The diffusion will take place also through a porous diaphragm. Thus two Gases, separated in mass, if brought together, will of themselves make their massive separation molecular; their unit is the molecule which is endowed with a force or sort of will to seek its own kind. Still the two molecules remain two, not combining chemically; their molecular dualism is what is asserted by diffusion.

3. *Absorption.* Many Liquids have the power of absorbing certain Gases in varying degrees. Water, for instance, will absorb one-fortieth its volume of nitrogen, but 729 times its volume of ammonia. This absorption is proportional to pressure and temperature; also the same Liquid has the power

of absorbing its share of several Gases and of retaining them together in itself. Thus the liquid molecule seems to be able to hold in its own fixity the unfixed molecules of Gases, so that they do not expand, or expand very little. The one appears to attract and keep the other; in this phenomenon there seems to be something analogous to capillary attraction, by which the solid draws and retains the liquid. In such a test the different Gases show a great difference of characters; it takes for instance 20 molecules of water to absorb one of oxygen, but these 20 molecules of water will absorb 9,000 molecules of hydrochloric acid, and toward double as much ammonia.

The absorption of the Gas by the Liquid may be conceived as a return to and adoption of the gaseous molecule (as spherule) by the liquid molecule, so that the latter dominates the former, stopping the expansibiiity of the one in the fixity of the other. Thus Gas when absorbed by the Liquid largely loses its salient trait, and assumes that of its absorbent in this regard. Evidently the liquid molecule by a kind of attraction has the power of curbing the expansion of the gaseous molecule. This same power over the air (Gas) the earth will show in the attraction of gravitation—a subject to be considered a little later. In the present stage we took the molecule as a whole; next we are to get inside of it and see its inner separation and workings.

II. Molecular Resistance of Gases. The counterpart to the expansibility of Gases is their compressibility. The gaseous molecule is a bound-pusher from within; but naturally becomes weaker and more compressible from without. The Gas, notably the air is easily penetrable, yet is very penetrating; its own passive separation becomes also very active, and tears liquid as well as solid asunder. It has weight yet resists (so to speak) its own weight, with a rebound which sends it afar outward in all directions. Air is implicit fire which appears in it when compressed to a point; that is, it manifests its negative consuming energy, which must be deemed its ultimate act of self-defense or resistance. It changes to liquid and to solid, which may also be taken as other forms of molecular resistance, which the air assumes under external assault or pressure. In these cases we see the inner dualism of the Gas; it yields and then resists, or perchance doing both together; this doubleness undoubtedly lies in the gaseous molecule itself.

1. *Pressure.* The greater the pressure, the less the volume of the Gas, other things being the same (temperature and quantity). Such is Boyle's famous law, discovered in 1662, and fourteen years later re-discovered by Mariotte, under whose name it still goes in France. This law has some peculiar variations which render it not quite true, even if sufficiently exact. It declares that the density of

a Gas is proportional to the pressure, indicating the difference between the gaseous character and that of the Liquid, which is almost non-elastic and resists compression. Boyle's law must be conceived to apply to the molecule whose expansion is counteracted and turned to its opposite by external pressure, yet always with an internal resistance which asserts itself when the pressure is removed. So it comes that through the medium of the gaseous molecule pressure can be conveyed.

2. *Transmission of the Pressure of Gases.* The external pressure upon a Gas determines its internal pressure outward, which is readily transmissible. The molecular resistance pushes in all directions for an outlet; the gaseous molecule seeks space for its suppressed expansion, while the liquid molecule almost unexpanded conveys its resistance. Thus the gaseous molecule becomes within itself the seat of struggle between the inner and outer forces, between compression and expansion. This inner division with its fight is hardly found in the liquid molecule. Air thus shows a deeper diremption within itself than water, which has no such inner self-separation and self-recovery, as it transmits its pressure immediately. But the molecule of air accepts the outer pressure and transforms it into an inner pressure, which then pushes outward in the form of resistance, and this can become a great power utilizable by man.

3. *Gaseous Pressure Directed and Multiplied.* The expansive power of the Gas, or its pressure outward must be confined in a closed vessel which can be tapped and emit the molecular energy. The most common example is the steam boiler, which can be heated. Thus the machine is again employed as in the Liquid, and indeed as in the Mechanical Powers, to transfer, to distribute, and to apply force generated outside of it. In the case of steam, heat is used to expand the molecules, the boiler to restrain this expansion which is drawn off by a pipe and directed to driving the engine. Thus the gas machine transfers one resistance to overcoming another of a very different sort, being in this regard comparable to the hydraulic press. But the gas molecule with its systole and diastole is capable of a far wider application than the rigid liquid molecule, which has no such inner contraction and dilatation (like a little heart).

Molecular resistance may be supposed to have spent itself when the Gas rushes out of its closed chamber into freedom, and takes its original place in the terrestrial adjustment. The throbbing molecule (for so we may imagine it in the present sphere) with its inner contraction and dilatation has escaped from its immediate prison whose confinement caused all the pulsations of its little heart, and finds itself in a state of liberation. But even thus it is not free to roam through the universe, it

discovers a new restraint upon itself whose character must next be considered.

III. MOLECULAR GRAVITATION OF GASES. It has been already stated that the Gas is heavy, and thus has finally to come under the influence of gravitation, in spite of its expansibility, whose strength we have just seen and measured. But this molecular resistance yields at last to its antagonist and the Gas gravitates earthward like other bodies—in which act it reveals new phases of its character. The weight of 100 cubic inches of dry air at an atmospheric pressure of 30 inches, and at the temperature of 16 degrees Centigrade, is 31 grains; carbonic acid gas weighs half as much more, and hydrogen one-fifteenth as much. Thus we may suppose that a molecule of each different Gas is drawn differently to the earth, and therein reveals a phase of its individuality, which, recalcitrant though it be, it has had in the end to submit to the terrestrial master. That the air is heavy or gravitates is strikingly shown by the air-pump.

1. *Equilibrium.* The great scientific act in the determination of atmosphere, or of the molecular gravitation of the Gas is the experiment of Torricelli, pupil of Galileo, which was first made in 1643. This was to equilibrate a column of air with a column of mercury in a glass tube closed at one end and inverted in a trough of mercury. It was found that 30 inches of mercury would balance the entire height of the air. The weight of

a square inch of mercury 30 inches high is about 15 pounds, which is taken as the unit of measure in this realm and is called an atmosphere. Pascal repeated Torricelli's experiment with water instead of mercury and found that it rose to 34 feet, or thirteen and a half times higher than mercury and hence that it was so much lighter—a fact which could be tested by the direct weighing of the two substances. The typical Gas is now measured and with it we can measure other Gases. The well-known barometer is based upon the Torricellian experiment.

2. *Undulation.* The equilibrium of the Gas can be disturbed, and there arises the undulation as in the Liquid. But since the Gas has not only the mobility of the Liquid but also its own restless ever-stretching expansibility, its undulating character is far more decided and active than that of the Liquid. Indeed the air is always in motion, has to be on account of its innate self-extension. The winds of the earth never stop and have a life of their own, which is set forth in meteorology. But the chief disturbance of the air produces what is called Sound, which is sensed by a special organ, that of hearing. The undulation of the stretched string calls up by analogy the oscillatory movement of the pendulum, and also of the Liquid. They show the same struggle between gravitation and radiation which causes the whirl of the sound-waves. These, however, are propagated not trans-

versely, like water-waves, but longitudinally, along the radial line from the center of disturbance, by means of condensation and rarifaction; the molecule propagates its contraction and expansion or its own inner process. This separation within (a kind of self-activity) of the air has been already noted in connection with the transmission of aerial pressure, which, then silent, has now gotten a voice, and utters its own internal movement. When this internal movement is regular and periodic, we enter the realm of the distinctively musical sound, which has the power of stimulating in the mind (or Ego) its own fundamental process (or Psychosis). Thus the outer and inner (mental) movements agree, and the sound is called accordingly agreeable. Says Helmholtz: "The sensation of a musical tone is due to rapid periodic motion of a sonorous body" (*Sensations of Tone* p. 8). Mere noise on the contrary is not periodic.

Moreover sound is capable of reflection, refraction, reduplication in echo and resonance. Thus the sound-waves will show their analogy to the light-waves. The periodic or self-returning tone can be organized into the science of music with its melody and harmony. This, however, we shall have to pass over, as well as other striking details of acoustics. The disturbance of the air which causes undulation has a tendency to gravitate toward an equilibrium, even if this be imperfectly attained. In this average atmospheric condition,

the air is heavy and the body in it is heavy, both being attracted by the earth; is there any comparative weighing of them, such as we observed in the case of Specific Gravity?

3. *Relative Weight.* There is an instrument called the *baroscope*, whose object to show to the vision the comparative gravities of air and a solid. A thin hollow sphere is balanced by a small iron weight; both are put under the receiver of an air pump, when the sphere descends, showing an increase of gravitation in comparison with the exhaustion of the air. This increase can be measured, whereby it is shown to be equal to the weight of the displaced air, which weight the small solid loses. Thus the principles of Archimedes, who discovered the Specific Gravity of the solid in water, holds true of the solid in air; that is, a body immersed in a Liquid or Gas loses weight in proportion to the weight of the displaced fluid. If therefore, a body be so constructed that it displaces its own weight of air, it begins to float; if it displaces less than its own weight of air it will rise upward.

Upon this principle air navigation depends, as well as water navigation. To utilize the aerial as well as the aqueous ocean for human inter-communication is felt to be a pressing problem of the present time (1909). Possibly it has been already solved, but we are all eagerly waiting for the final evidence. The start was made in 1783 at Anno-

nay, France, by the brothers Montgolfier, with their balloon filled with hot air, for which the physicist Charles substituted hydrogen, lightest of Gases, the same year and made an ascent. Since then many forms of the balloon have been invented, the chief aim being the adequately dirigible balloon. But the aeroplane with its driving machinery will probably be the air-ship of the future.

So we have made the essential round of the Gas with its expansible molecule, which still gravitates in spite of its own strong resistance to gravitation. The second Fluid thus shows its inner doubleness, its rise and fall, its expansion and compression, its degravitation and its gravitation. We may say that the diacosmical principle has herein manifested itself intensely, but at last has had to yield to the cosmical principle. The question rises: Is there a Fluid whose expansion is not finally overcome, whose gravitation is somehow counterpoised by degravitation? Is there a third Fluid, next in order, whose molecular equilibrium is not of the Earth but of the physical All—the balance between Cosmos and Diacosmos? Science has felt itself necessitated to adopt such a Fluid, though as yet speculative.

This Fluid is the Ether. If we consider a column of air, it becomes more and more tenuous as it ascends from the earth; still it is heavy and gravitates. Each molecule may be regarded as the arena of a continuous struggle between attraction

and the expanding resistance to it, or between gravitation and degravitation, with the victory of the former. Thinner and thinner becomes the air, and weaker its molecules, but the conflict goes on till we may conceive the last molecule, surely more than a hundred miles high, in its ultimate rarification. This molecule still is heavy and gravitates, overcoming all its expansion and degravitation. But the next step is to the conception of a fluid molecule which indeed gravitates but also degravitates equally, which thus cuts loose from the earth and from all particular bodies, and has its own independent process of gravitation and degravitation throughout all space. Such a molecule may well be deemed the universal molecule, presenting to all special forms of matter one or the other side of itself. For instance the Sun, attracting by gravitation, can reach the attracted body through the gravitating side of the etheric molecule; on the other hand solar degravitation, such as Heat and Light, can find its corresponding medium in the degravitating Ether.

The Newtonian universal gravitation is not strictly universal, but particular, and takes place between particular bodies. Consider the stellar world; it is a vast reservoir of special attractions going out from every star in every direction. Gravitation to be truly universal, must be of the universal body, or rather of the universal Matter, not merely of the particular body. This uni-

versal principle in its varied aspects we shall next take up.

III.

The Ether.

We have now come to a hypothetical Fluid, a purely speculative entity, but getting to be, if it is not already, the central subject of investigation in physical science. It has never been isolated as a real thing, it is simply an inference or an idea; still physicists are saying with a good deal of unanimity that they believe in it as fully as in their own existence. It is not or has not been amenable to direct experiment, and thus brings the scientific mind to challenge one of its fundamental canons. Ether is the supersensible springing from and capping the sensible. Certainly a curious sight it is to behold the vast army of scientists cutting loose from the world palpable and taking flight to a realm impalpable, which cannot be seen, heard, tasted, smelt, which seems to be invoking a new sense for its examination. Such is the most striking psychical fact in the Natural Science of the time; it is getting more and more supernatural in its way, while violently condemning the old supernaturalism; Physics is galloping toward Metaphysics, though not failing to hurl curses at its old foe into whose domain it is rushing.

Ether, then, is the problem of the Diacosmos; its existence at present is seldom doubted, but

its character is under the fire of fierce discussion. It has become the arena of every diversity of opinion, which has free play for exploitation, since no statement of this realm can be caught and held to the test of direct experiment. And still one cannot help feeling that this confusion is evolving toward order, as ancient Chaos did in the poem of Hesiod. In fact Ether, both word and thing, seems to hover over the whole history of science from the beginning down to the present, in a sort of etherial pillar of cloud, very elusive, but very persistent. The old Greek philosopher, Anaximander, of Miletus, appears to have first thrown out the thought as well as the vocable, in his search for the ultimate prinple of the Universe, which he held to be *aither* (often called *air*). Interesting is it to see Sir Isaac Newton tampering with the subtle Fluid which he names Ether. The law of gravitation he found and formulated as all the world knows; but he was well aware of a something lying back of gravitation, a medium in which and through which it acts. Says he in his famous letter to Boyle: "I will suppose Ether to consist of parts differing from one another in subtlety by infinite degrees"; the letter runs on constructing a theory of this Ether, by which he might be able to explain "the cause of gravity." But Newton never succeeded in putting together any experimental contrivance with which he might grip and exam-

ine a speck of this infinitely subtle substance. And that wonder-working mathematical machine of his brain could never quite be adjusted so as to measure this Ether. Indeed Newton, as all now see, was precluded by his corpuscular theory of light, from taking the first step in finding the constitution of the Ether, which began to hint a little about itself in Young's experiments showing the undulation of light, during the first years of the nineteenth century. Evidently an "all-pervading Ether" hovered before Newton's mind during his whole scientific life, as a kind of background of the phenomenal world which he was unable to enter. In fact his greatest piece of work, the theory of universal gravitation, necessarily calls up such a medium as its originative source. For Newton did not cling to the belief of an *actio in distans,* though we have all been taught so in our school-days; he may have fluctuated at times. Here is a strong statement in one of his moods (third letter to Bentley): "That one body may act upon another at a distance, though a vacuum, without the mediation of anything else . . . . is to me so great an absurdity that I believe no man" of competent judgment ever fell into it. This was probably Newton's dominating view, though in other passages he is not so emphatic. In general, however, he declares: "I do not take gravity for an essential property of bodies." It may be added that the science of to-day is still engaged in a

mighty wrestle with Newton's unsolved problem of action at a distance through the mediation of an omnipresent Ether, which is supposed to be behind and somehow to determine universal gravitation, possibly by mechanical impact.

Accordingly Ether, in the mind of the scientist, is a postulated universal Fluid, co-equal with all space and filling the same, inter-planetary and also inter-stellar, embracing the Heliosphere as well as the Cosmosphere, between which it forms some kind of unity or connecting tissue. The Fluid universal it is called, and like the universal it can only be the product of the thinking All-Self, whose thought we have to re-think or re-create. Ether is not merely subjective, it is existent, it is already made though we, each Ego of us, have to re-make it for ourselves. It is a medium, actively so, or that which mediates, having thus mediational power which in its way inter-correlates the whole physical universe. The attraction of gravitation is declared universal, extending its reach to the remotest spaces of the Pancosmos, and binding all Matter and Motion together, probably through the mediation of Ether. This transmits force which is a mode of Motion, in the form of radiative waves or vibrations: in this sense it is radio-active, as well as in itself probably, for we now hear that everything is radio-active, especially in the realm of the Diacosmos. Etheric molecules radiate gravitational lines from every cosmical body to all the

rest, and need but its material presence to stimulate the radiative act of gravitation through the spatial immensities.

Ether may be regarded as the primordial protoplasm of the physical universe, the earliest substance of Nature, from which all her different forms have evolved. Planets, suns, nebulæ were in the beginning the one single protoplasmic material, the potentiality of all the others which have since evolved. This thought carries us back to the two elements with which we saw the Cosmos starting: Motion and Matter. We conceive the Ether to be these twain still in their primal unity, before they had become separated from each other. If all things of Nature are sprung of those elemental twins, Motion and Matter, there was a time and a condition in which they were not born, but sleeping united in the same womb of the All. In this view Ether was the first separation of Nature from the universal Self, the earliest form of the Pancosmos, in which all evolution lies implicit. We might call it the pancosmical egg out of which were to hatch all the stars and what they contain.

Next this primordial protoplasm is to divide within itself, as it is the product of division and so is inherently divisive. Such division of it is explicitly Motion and Matter, with the involved quantitative element (as all division involves quantity or how-much). Ether, then, is originally composed of Motion and Matter as yet un-

differentiated, the universal substance filling all space, and the first created or separated thing of Nature. Thus we are whirled back to the beginning of the Cosmos, whose two first elements we find to be one in Ether.

But we must reach out to a third conception in this domain, namely, the constitution of the protoplasmic Ether, which is composed of particles or molecules smallest of the small. Each molecule of it we have to think as made up of the primal elemental constituents, Motion and Matter. Very different is this from a molecule of water or of air, which have two chemical elements conjoined; but these two, Motion and Matter, are far more primary than any chemical elements, indeed they are the elements of all elements. Such is the unique particle or molecule of Ether, which thus must be conceived as the primal constituent of all succeeding Nature, not only on earth but to the farthest regions of the Pancosmos. The electron, which now dominates physical science, is usually defined to be a simple charge of electricity, pure force without material substrate. Such a view is one-sided, indeed inconceivable. Motion (or energy) without Matter, or Matter without Motion exists not in Nature. In this electrical age the electron unduly enthrones electricity, which is in reality only one of the radiants, only one manifestation of the Ether as universal medium. It is, therefore, a mistake to say, as is so often said just now that

Matter is nothing but electricity, or one form of energy or Motion. Hence the electron calls for and indeed is pushing out beyond itself toward a truly universal principle or element which must lie in the universal protoplasm of Nature, and which can be made the constitutive principle of all forms of the Diacosmos, as well as of the Cosmos.

Such an elemental idea we may name the etherion. We say idea, for such an object, though conceived as real, remains supersensible and ideal. But the speculative side of physical science, as already observed, has now become uppermost and must work itself out in this ideal domain to scientific completeness, at least during its present epoch of efflorescence. Hereafter a new trend may set in. Coming back to the etherion, we may note the rapid evolution toward it during the past century, in the atom of Dalton, in the ion of Faraday, finally in the electron of the present time, whose very limitation must evolve the etherion of to-morrow. Only in the universality of the Ether can the universal element or constituent find its realization.

According to the foregoing conception, the Ether is a Fluid, the third Fluid in the first stage of the Diacosmos. Some have denied its fluidity; Lord Kelvin calls it a jelly. But all assign to it a wave-power, an undulatory character when stimulated. We conceive it likewise to be molecular in constitution like the other Fluids. Still its molecule is

very differently constituted from that of water and air for instance. The first (water) is a compound of chemical elements, the second (air) is a mixture of chemical elements, the third (ether) is an immediate union, not of chemical but of the original elements of the world's protoplasm. Such a molecule we have dared call an etherion, a term constructed after the analogy of the ion and the electron, its precursors in the chase for the ultimate physical principle. All three molecules of fluidity, the aqueous, the aerial and the etheric, have a common elemental constitution in the conjunction of two elements, yet with the differences already mentioned. Thus they form the cycle of Fluids in the Diacosmos; the Ether (the third stage) may be conceived as sharing with water (the first stage) the latter's chief mediational characteristic, namely the transverse wave-movement, which vibrates the radiants transversely through all distance.

And now for a difficulty which naturally comes up in the mind. If these etheric molecules be spherical, they do not fully fit together, there must be a void between them, very small indeed but still real. Thus arises an inter-etheric problem, which seems to indicate that the Ether is not the universal Fluid, but is at last limited by empty space between its molecules. On the other hand if these molecules be absolutely expansible, they must occupy any such void.

In this connection the Ether can be imagined as

the ocean of the universe embracing all extension, if it be not just that which extends spatially. In this universal ocean are swimming all the celestial bodies like islands, multitudinous certainly, but the largest of them are very small in comparison with the magnitude of their environing Fluid. It has no surface on which its more solid substances may float; or rather its surface is everywhere, is a potentiality like point, line, and surface in space. Each star or planet has to geometrize it with motion, for it is also the possibility of all measure. The Ether as a totality may be conceived as the one single all-embracing, yea all-engendering ocean of the Pancosmos, out of which everything else in Nature is to follow, and to which it is to return. The old Greek philosopher, Heraclitus, with his universal flux seems to have glimpsed the Ether.

It may be added that each of the other two Fluids has its ocean likewise, not universal but special and limited, indeed only terrestrial. Water forms our great mundane ocean, covering according to the common estimate three-fourths of the globe's surface, and seeking a steady equilibrium in molecular lines of gravity toward the common center of the earth, to which it seems tied by radiating ropes of force. Air forms the second fluid ocean completely surrounding the globe and covering it many miles deep (put now at a hundred) with its ever-expanding particles or molecules. Still the air is heavy and in spite of rebound is

brought at last to assume also molecular lines of gravity toward the terrestrial center in a kind of radiation. The atmosphere has a very indefinite upper surface to its ocean, but the lower surfaec or bottom is sharply marked by the limit of land and water, both of which it embosoms. But the third fluid ocean, the etheric, is the unlimited one, infinitely expansible and expanded in space, not only embracing the other two oceans but penetrating them to every molecule, which can offer no resistance to its subtle insinuation, being of it originally. Such are the three circumambient oceans in which our globe reposes, though this is no boundary against the third. Note the three degrees of approach toward universality in them: the aqueous ocean is but partial on the earth, having to share its dominion with the solid land; the aerial ocean is universally environing as far as the globe is concerned, but limited to it; finally the etheric ocean is not bound by the terrestrial tie exclusively, as are the other two Fluids, but sweeps on and on to spatial universality, evidently in defiance of all gravitation.

Here we are brought face to face with a problem as yet unsolved: Has the Ether any weight, however slight? And in general, what is the relation of it to gravitation? The most expansible Gas on earth is at last overcome by attraction; but in the Ether the expansibility of matter has quite reached the point of equaling or equilibrating the power of gravitation. Moreover the Ether as uni-

versal Fluid lies in many fields of gravitation, yea in all of them absolutely; one field cannot help counter-poising the field of another, and so there rises in the Ether a kind of universal interaction of one gravitating force or perchance wave with another. In fact universal gravitation as applied to the universal Ether undoes itself; the sum of all attractions in every direction must be equal at each point in the Ether. The attractive force of single bodies for one another is mutual, and varies directly according to the mass and inversely according to the square of the distance. But these conditions do not hold in the Ether, which is all mass and which is everywhere or is all distance. Gravitation pertains to bodies individualized and separate, not to the unseparated universal body, or just the body of the universe as physical. Gravitation is really particular in spite of its ordinary predicate; if universalized it becomes self-contradictory. Attraction is of bodies outside of one another; but what can be outside of the Ether to attract it, being itself ubiquitous and universal? Can a universe, even if of Matter, be heavy? Only if there be two or more universes for mutual gravitation—which is of course a contradiction in terms. Gravitation is thus an externality which must become internal and so vanish as external in the universal body, the Ether.

What is this internal gravitation which we conceive to be inherent in the body universal, the

Ether? It is always moving in and toward its own, itself, not outwardly toward something else. We now must come back to the conception of the etheric molecule or the etherion as the primal oneness of Motion and Matter, or as Matter moving and Motion mattering (if we dare coin such a word). It may be here added than in one sense gravitation can be and is called universal. It holds of all particular bodies, which as separated gravitate toward one another. But this presupposes that the universal Matter has been specialized into distinct bodies, which then mutually attract, but before such attraction of particular matters, there is the original Ether whence they came. Gravitation is accordingly a special, particular act between particulars, even if it holds of all of them.

We have now come to the two extremes of the physical universe—they are often called infinites by way of emphasis—the infinitely large or extended, the Ether, and the infinitely small or divided, the Etherion. Both belong together in one substance, which is the primordial protoplasm of total Nature. We may look at them in another aspect: the Ether is the extreme of the Cosmos, while the Etherion is the extreme of the Diacosmos. In their unity we may see the original unity out of which these two chief stages of Nature have unfolded into difference. The common molecular structure of the Pancosmos we find in this primal mother-element of Nature.

Another characteristic must be emphasized: there is everywhere and always Motion in the Ether—universal Motion in the universal substance. In this way it is supremely the medium of Motion; it is the bearer of all special forms of Motion; we may deem it the vast reservoir which has to be tapped before anything can be moved. In the sweep of my hand I have to draw upon the store of universal Motion and make it particular in my case. That store is around me and everywhere else in the physical universe. The Ether is, then, the reservoir of all force and energy, which are but phases of Motion. The problem with man is, how can he get hold of it and direct it to his end in greater and greater volumes. For he does not make it at all, it exists primordially as universal, but it has to be specialized. All movements from the flight of a piece of dust to the whirl of the planets is a specialization of Motion, a more or less extensive draught from its well-head. At the same time we are not to forget that this Motion has its material counterpart or envelope of Matter; the Ether is their primal protoplasmic oneness in its smallest particle or molecule, which we call the Etherion. Physical Science which once gave all to Matter, is now inclined to give all to Motion, in some of its forms, as force, energy, electricity. Each is a one-sided stage in the conception of total Nature, which cannot do or even be without both in the greatest as well as in the least.

The Ether as fountain of Motion has many ways of being tapped or perchance stirred to activity. It is the ever-moving medium, mediating all special Motions yet keeping its own universal Motion. We might call the Ether pure Motion, as some have done; but it is just as well pure Matter. Now there are various degrees of exciting this universal medium and of sharing in its first nature, which is universality. The walk of a man has relatively little participation in this medium, still a little; the rotation of the earth has considerably more, and light very much more; but most of all gravitation comes nearest to sharing in pure Motion, and hence is often called universal. Attraction of body for body seems to act instantaneously and goes right through all obstacles so far as we are yet able to discriminate. The Radiants—Heat, Light, Electricity—are supposed to start waves in the Ether which largely correspond to its original elemental Motion—hence their velocity. But they do not coincide; the electron is not as universal as the Etherion. Wireless telegraphy has found a way of participating deeply in the etheric medium with its universal Motion, and of making it carry a message instantaneously (as far as we can tell) many hundreds of miles. It stimulates Motion and Matter almost (though not quite) at their creative source, and gives an impress there which may yet be borne to the stars. For Ether is the mediational ocean between all

particularity in the universe. We may call it the All-Ether, first natural product or separation of the All-Self in its complete process as Pampsychosis. A curious fact of the time is that some scientists regard the Ether as the original soul-stuff of humanity, out of which consciousness and mind have gradually evolved. One asks in vain, Whence this soul-stuff? It is interesting and significant that so many naturalists are inclined to project into Motion and Matter an elemental soul-form, and trace its evolution upward. The difficulty of origin, however, still remains. Undoubtedly all Nature has a psychical strain and must be psychically ordered as a part or phase of the universal Psychosis, or of the psychical process of the universe (Pampsychosis). From this indeed Nature sprang, and she always bears the stamp of her origin.

At this point one may well ask: Will man ever be able to tap the Ether immediately at its source, which is verily the source of universal energy, that is, of the energy of the universe? Will he yet make a machine which will directly employ or utilize Motion in itself, that is, Motion of Matter in its original purity? That will certainly be the machine of all machines, for the machinery hitherto constructed merely catches some little drops of power from this unlimited ocean of universal energy, and that in an indirect way, through some intermediate material. The simple Mechanical

Powers we have seen using primarily animal force; the hydraulic press seizes and multiplies the might of the liquid, water; the steam engine concentrates and directs the energy of a gas or vapor; air likewise is compressed and thus made a medium of power in many ways by various mechanical contrivances. But all these materials—solid, liquid, gas—are intermediate and derived, so are also their various energies; they get themselves as well their powers from the one original material Power, the Ether. Now the cry, the aspiration is for the universal Machine which will function the universal energy, the primordial Motion of Matter itself. Associated machines we are already getting; electrical energy is segregated and stored by machinery in vast reservoirs which can be tapped and turned to thousandfold other mechanical purposes. Likewise liquid energy is gathered from a thousand streams and united in a huge dam (a kind of elemental association) whose power is drawn off by a thousand conduits and made to turn mill-wheels or to generate other forms of energy (a good instance is Niagara, to which can now be added the artificial reservoirs constructed in the Rockies and in the Alleghenies). Truly an image of man's own Social Whole is this, of his Economic Order specially, which gathers up all the little streams of production into great centers of aggregation from which these products are distributed to the millions. But the primary original ag-

gregation of total energy, the etheric ocean, has hardly yet been drawn upon directly by the mechanical contrivance, though in wireless telegraphy we seem to be getting a little pinch on it through an electrical device.

The nebular hypothesis of Kant and Laplace starts the universe with nebulæ, the original Matter in a state of extreme tenuity which proceeds to greater and greater condensation. In this theory Matter dominates, though Motion and Energy are not left out. Given that nebulous fire-mist, then the universe follows or rather evolves. This view has had a great vogue in our evolutionary century and is still largely held, though not without sharp attack. Of course we must in time peer behind the fire-mist and originate the origin, or evolve the evolution. Thus we are borne back to the Ether or something like it.

On account of its diverse forms or, better, its manifold specialization, conjecture has sometimes set up many different Ethers, each with its particular character. But we are to see that the universal Ether particularizes itself into these diverse forms of itself in adjustment to its excitant, or, as this is often called, its disturbance. One Ether there is, then, not typical as water is the typical liquid, or air the typical gas; the Ether we must regard as the universal Fluid, including all its forms and indeed creative of them. It has the universal molecule which is verily the molecule of the Universe as physical.

The Ether is usually designated as imponderable; in a sense this is so and in a sense not. It has its material constituent, and would thus need to be heavy. Its gravitation must be conceived as pan-cosmical, not terrestrial specially nor solar; it gravitates not earthward or sunward but allward. It is truly universal and thus is the medium of all particular gravitation. It gravitates everywhither and so must also be degravitating.

The Ether propagates specially by waves, by an oscillatory movement in its substance from the source of its excitation. These waves move in every direction from the center and thus in form at least show radio-activity which belongs to the Ether inherently. Moreover they are transverse, having an up-and-down movement similar to water, not a to-and-fro movement like air.

Ether, the most attenuated and elastic of substances, is said by Lord Kelvin to be more rigid than steel; its enormous velocity gives to it such rigidity. This fact may be compared with the effect of velocity upon another fluid, water, which falling five hundred meters through a tube could not be penetrated by a saber stroke (Le Bon). The radiant excitation of the Ether must come into rapport with the velocity in order to be borne by it. For it is a constant quantity; Heat, Light and Electricity have all been found to have a speed of 186,000 miles per second; the inference is that their common medium, the Ether, has their

speed or has it for the Radiants, which, however, may not be able to adjust themselves to the full etheric rapidity.

It was a great triumph for science when the three Radiants—Heat, Light and Electricity—were co-ordinated by their common velocity in the etheric medium. The first necessary step may be deemed the work of the Danish astronomer, Roemer, in calculating the speed of light. The next great step was taken when Young showed the movement of Light was undulatory, not corpuscular. Hertz's discovery that Electricity moved with the speed of Light, put the three Radiants into a common class, the second of the Diacosmos, though each has its own special characteristics. Still this constant velocity of the Radiants has been recently assailed, as have so many other transmitted dogmas. For instance it is claimed that experiment has shown Light to vary slightly in speed according to its varying intensity.

The Ether seems to show the character of water in a number of points. Its wave-motion is transverse like that of water and unlike that of air. In its rigidity through velocity it resembles water. In water begins the visible special undulation of the Fluid which in Ether becomes invisible and universal. The Ether has also not a few characteristics in common with the air. All three are radiative of Motion, and therein show their native radio-activity, after the general form in which we

conceive this term. The statement is frequently made that the air cannot transmit Light or any of the Radiants since the air-wave does not move transversely (that is, in harmony with the etheric Fluid), but longitudinally. In this respect Ether is like water. Moreover its molecules are supposed to be rotational, and probably on this side receptive of the excitation of the Radiant, which is also rotatory. The rotatory movement of the etheric molecule has been declared to be so great that it projects light, like that of the Sun, far beyond the Solar System into the Cosmosphere.

The conception of the etheric molecule as material on the one hand, yet as imponderable on the other, is the grand dualism in this sphere; to overcome which scientists are wrestling. Here we may note the solution of the distinguished Russian chemist, Medelejeff. He declares it to be a chemical element, whose atomic weight is a millionth of that of hydrogen, hitherto deemed the lightest element. He puts Ether into his zero group along with helium and argon, labeling it the x element (gaseous) of the chemical totality, which he has so wonderfully organized in his Periodic System (to be mentioned later under Chemism). Such a theory regards the Ether as material and heavy. Of course it at once runs upon a difficulty: if the etheric molecule has weight, what is attracting it? Or, as universal, how can it have any particular attraction which finally determines it? The fore-

going theory leaves out the real difficulty: that of degravitation, which must be equal to gravitation in the Ether. Yet Mendelejeff's idea has its significance; it at least suggests the original element, the universal chemical element, from which all the others have been evolved and to which they may be reduced. Thus the Ether chemically considered may be taken as the primordial unit of the eighty (more or less) elements of chemistry.

When we come to Gravitation, we are met by a wholly new potence of the Ether as medium, which now seems to manifest itself in a new power, quite as absolute Motion. Heat, Light, Electricity, have no effect upon the function of Gravitation, which acts as if independent of these diacosmical energies. It is not obstructed by intervening bodies, physicists say. It is constant, unchangeable, inexhaustible; it is not diminishing as are the forces of the Diacosmos. According to Laplace its velocfty has to be at least fifty million times greater than that of Light. Naturally the mind speculates about the connection between Gravitation and the Ether. Bodies gravitating toward each other manifest their unity as Matter, but this same manifestation as attraction is quite one with the universal Motion of the Ether itself. Gravitation partakes of two Motions: the universal and the special; as universal it is instantaneous, ideal, purely etheric; but as special it is retarded, real, measurable: that the Sun attracts the Earth is the universal instan-

taneous Motion; that the Earth moves toward the Sun is the particular finite Motion. The first was deemed once the sudden *actio in distans,* but is now regarded as etheric action, the second is the existent terrestrial movement in its orbit. The diacosmical Radiants also show this universal side of Motion. We may repeat that the universe as a totality cannot be gravitative without contradicting itself, that is, without negating itself as universe. Only as particularized can it come under the law of Gravitation. In this state of particularity Newton grasped it and formulated the aforesaid law.

To a limited degree we may conceive a body as radiating Gravitation in every direction. The Sun is the center of attraction for all bodies of the solar system, as it is the center of emission of light. In both ways it stimulates the Motion of the Ether, but very differently; performing in the one case its cosmical, in the other its diacosmical part. or that of unification there and of separation here. It strives on the one hand to bring all its Matter to itself, then on the other it strives to eject its own very self as energy into the circumjacent space.

This vast pancosmical reservoir of Ether with its ever-moving molecules—what is the direction of its Motion? It would seem to be the connecting element between all portions of the Solar System; then it must sweep out into the Cosmosphere with which it connects the Heliosphere; it is the Ocean

which washes every nook and whirls into and out of every bay of the Pancosmos. The universal Fluid of the physical universe we conceive it and imagine it to be swirling through our relatively little corner of the Sun's dominion, and then returning in its round of inter-stellar spaces.

To give any detailed organization of this third Fluid, would be even more hypothetical than the hypothetical Ether itself. It is only possible to present some intimations derived from the two other Fluids, the Liquid and the Gas, which we have seen showing a common underlying order, which order we may conjecture to have some analogies in the Ether.

1. If we take the etheric molecule as spherical, we must add to it a complete expansibility or the possibility of assuming all shapes. Hence the molecularity of the Ether is not to be conceived as discontinuous (Lord Kelvin and many other physicists) or as granulated. Such a view implies the rigidity of the etheric molecule, which does not comport with its absolutely expansible nature. Moreover such a view calls up an inter-ether as limit to the Ether, thus denying the latter's universality. In such a case, too, the series of atom, ion, electron, would not stop with the etherion, but would go on *ad infinitum.* That is, between the etheric molecules there would have to be conceived pure space or some new different Ether with its molecule. But this conception denies the

very nature of the etherion, which is the ultimate germ or blastule of the Pancosmos.

2. The transmissive character of the Ether must be deemed its chief property which takes the form of undulation like the other Fluids. Yet it is also very different from other sorts of undulation, being the universal one, or that of the universe as physical. It is a continuous equilibration of Motion and Matter, which is the original source of all energy; it is the primordial oscillation between Cosmos and Diacosmos, gravitating and degravitating. Attraction, being of all directions, keeps forever acting yet also counteracting itself: thus arises and continues the undulatory process of the Ether, weighting yet unweighting itself, oscillating not so much in Time as with Time itself (see preceding p. 64). It may be added that such an etheric undulation is a quantum and hence measurable, though as yet mathematical measurement has been able to seize it only in some of very limited manifestations.

3. What we have called the molecular gravitation of Fluids, in the case of air and water for instance, is determined finally by the pull of the earth. But now in the etheric molecule this particular terrestrial attraction is countervailed by what we may name universal attraction; we conceive the Etherion gravitating specially, but also overcoming such gravitation, that is, degravitating. This we cannot conceive as a dead piece of matter (like Lord Kelvin's jelly), but as a perpet-

ual process in itself, which fact makes it the universal medium of all gravitation (Cosmos) as well as of all degravitation (Diacosmos),

Yet with a difference which must be here noted. It is evident that there is an inner movement, we may indeed say, an inner conflict in every Etherion as well as in the grand totality of the Ether; its material unity (expressed in gravitation) is first and cosmical, then comes its strongly separative and diacosmical act of assailing and undoing this gravitative unity, whereby it degravitates and forms the basic undulating process of itself as universal medium. The result is that the etheric molecule, when stimulated by a Radiant, such as Light, is already occupied at home by its own task of degravitation, and so is in a manner preoccupied, using a part of its energy for its own activity. In response to this excitation from the outside by a Radiant it can give only a share of its energy which is thereby limited, partial, and accordingly measurable in space and time. On the other hand this same etheric molecule, when stimulated by gravitation has no such inner self-opposition to overcome as in the case of degravitation, and hence is practically endowed with unlimited motion. Such is our solution of that problem which has so deeply troubled the physicist, and which may be stated in a special case as follows: Why does light travel with a limited measurable velocity, while gravitation is seemingly instanta-

neouś and immeasurable? The etheric molecule has to unbalance its own gravitation before taking up and transmitting light; thus it has double duty in the case of the Radiants—which it has not in the case of simple attraction. At present we can put the contrast in this way: the Ether in response to gravitation, universally gravitates; while it, in response to degravitation can but partially and specially degravitate.

Here we must bring to an end our little treatise on the coming science of Ethericity with its two chief elements, the Ether and the Etherion. It is as yet wholly speculative, but altogether necessary, even in the opinion of the hardest-headed experimentalists. It is getting to be acknowledged that Electricity, which is having such a vogue in physical science through its practical side, goes back to and rests upon Ethericity.

But it is time to pass to the power which rouses, excites, stimulates this etheric medium in its own diacosmical fashion. We call this stage the radiant Diacosmos, being the second stage, which shows its basic separation in the two principles, the stimulating and the mediating, both of which are next to be taken up.

CHAPTER SECOND.

THE RADIANT DIACOSMOS.

Not the molecular principle now but the fact of radiation rises to view and becomes the fundamental characteristic of Nature. We pass from the Fluids resisting gravitation indeed, but tending to drop back under its control, to a new group of appearances in the Diacosmos, to which we shall give a special name, the Radiants. These are Heat, Light and Electricity, which have the common trait of radiating from a center of excitation. Thus they manifest attraction reversed and turn to work the other way from that which we have seen in the Cosmos. Instead of bodies being drawn together by gravitation, they now seem to be separated and repelled throughout the physical universe. Cohesion is not only negated but is turned to its opposite; a force which it held fast and made to work in harness, has broken loose and dashes out mightily in every direction toward the extremities of the Cosmosphere. The light of the sun and stars gives evidence of such a release of energy in the remotest regions of Space. They all show Radiation, which can only mean a liberation of imprisoned energy which reverses gravitatation and destroys cohesion.

Of course one cannot help asking what or who

has broken open the prison of the Cosmos and sent its freed inmates streaming forth toward infinity? It may be viewed as Nature's grand work of deliverance, her mighty diacosmical act, or more properly a stage of it, the second. The first stage of the Diacosmos we have already traced in the Fluids; the next stage is the present one, the Radiants, as we shall name them together. Ultimately we have to see this movement as psychical or rather as pampsychical, Nature being but a phase or form of the universal Self. Motion (the Separating) and Matter (the Separated) are now revealing one of their special manifestations in the course of the total evolution of Nature; we may call them for the sake of analogy, the Radiating (the Radiants) and the Radiated (the Fluids, especially the Ether). Thus we are to discriminate the two-fold character of the present stage: the radiating energy, or the side of Motion, and the radiated medium of it, the side of Matter. A new kind of impact we shall witness here, a kind of colliding Diacosmos, homologous with the colliding Cosmos already set forth (see p. 172).

If we compare the Radiants of the present stage (Light, Heat, Electricity) with the Fluids of the preceding stage (Liquid, Gas, Ether), we observe that the latter are reacting against their material attraction, and also they are seeking to separate from their cohesive unity. But they have to submit to gravitation though resisting it; they

are still material though in a protest against Matter. The mobility of water undoes cohesion but yields to gravitation; the expansibility of air assails gravitation but has at last to submit, being heavy; Ether is conceived as far more mobile than water and far more expansible than air, quite to the point of equilibrating Motion with Matter; still it is held to be molecular and material, it is Matter degravitated, quite deprived of ponderability and so infinitely yielding to radiation. But, when all is told, the Fluids are not completely separated from gravitation, they are always returning to equilibrium with it after disturbance, they cannot overcome it fully in spite of their resiliences and reactions from its compelling power. So much for the Fluids.

But the Radiants have properly no such rebound to gravitation; in accord with their name, they ray forth without returning to their gravitating source, their separation or dissociation is complete. Thus the Diacosmos has realized itself in its division from the Cosmos.

Radiation may be taken as a kind of *actio in distans*, but the reverse of that of gravitation. The ray of light streams out into the distance against attraction; it is repellent, yea self-repellent to the last; it is in an unceasing flight from its origin and from itself. It is separation *per se*, while attraction strives for unity, and works from afar. Truly the unitary Cosmos has been transformed into the

separative Diacosmos. Nature seems to have wheeled about in Heat, Light and Electricity, and to be rushing outward as if to get away from herself, though we may see in the end that she is by this route really coming back to herself, as a whole. Certainly the center of gravity in the universe seems to be uncentered, literally exploding in every direction. Radiation inverts the former cosmical movement, it is reversible gravitation.

In the extremely responsive, we may say sensitivized Ether, the Radiants chiefly manifest themselves in successive waves. Already all the molecular Fluids have shown an undulatory character, even Space, Time, Matter, were not without their oscillations, as we have seen. But these were struggles which sooner or later lapsed into equilibrium; they all gravitated at last to their cosmical center. But the Radiants thrill eternally toward the circumference of the universe; they speed for liberation upon wave after wave, through the unobstructed but not unfilled Space.

But next we ask about the source of this radiation? The striking fact comes to the front that such source is for us found in the Sun, which we have already seen to be the center of gravitation for the planetary system. So we have a diacosmical Sun as well as a cosmical, yet both are one; the great luminary is endowed with two opposite yet fundamental qualities. If it is the unifying body of the Cosmos or of one part of the

same, it is likewise the separative body of the Diacosmos; if it attracts all, it divides all. In its immediate vicinity it seems to allow no compounds, it tears them asunder, a drop of water falling on it would not become merely steam, but hydrogen and oxygen. It seemingly permits no solids or liquids near it, but turns them into separating gases ever repellent. It will have nothing but elements, the irreducible ones of Nature; thirty-six chemical elements have been distinguished in the spectrum of the Sun with others in doubt; possibly they are all there in their original elemental form. Calcium in enormous quantities furnishes the intense limelight illuminating the planets and piercing the starry depths of the Cosmosphere. Much carbon is radiating thence, particularly from the solar clouds; but strangely no gold has yet been found in the golden Sun. Other metals or elements it appears to have which are unknown to our earth. Helium was first noticed in the Sun by Lockyer, in 1868, but was found in a terrestrial mineral (clevite) by Ramsay, in 1895. The Sun is our concentrated Diacosmos, yet decentering itself. From it speed the three Radiants which are now to be considered. At the same time we must not forget that the Sun, if radiating, is also gravific; it is actively centripetal as well as centrifugal in itself, it causes all within its sphere of influence—the Heliosphere—to seek it and to fly from it.

The earth attracts its own separated bodies, but

hardly répels them, though it stops them on its surface and keeps them from its center. Now the Sun repels itself as material, radiates itself, being inherently self-separating down to its smallest particle. For this reason it is supposed to be slowly dissolving, consuming, and exhausting itself in its very radiances. Emphatic is the scientific view at present that the Sun never gets back fully what it gives out, and so is burning up. Heat, for instance, is its very self-dissolution, which it rays out from itself through its system and beyond, warming our earth on the way with its slowly ebbing life-blood. From this aspect of the case the Radiants are forever carrying off and dissipating the Sun's bank-account of energy. They are really negative forces which are certain in time to negate themselves. The laughing face of the sunrise is but a dying smile of ancient Helius. Possibly some millions of years hence the terrestrial problem will be, How can we save the Sun? With a little shudder for posterity, we may pass on.

Psychically considered, the Sun has the unitary stage in gravitation, and also the separative stage in radiation. But science affirms that there is no return for it out of self-separation, that it has in itself no recovery from its diacosmical dissipation or universal debauch. Like Hans Breitman, the Sun is declared to be solving the problem of the universe "by one eternal spree". Undoubtedly the Diacosmos is the separative stage of the

total process of Nature, and this separation permeates it, is its fundamental characteristic. The Fluids, the Radiants, the Chemical Elements have all this trait in common. The Diacosmos seems superficially the anarchy of Nature; still it belongs to her complete harmony, if this can only be grasped aright. Hence it comes that the proper ordering of this diacosmical phase is for us the redemption from chaos, the grand rescue of the soul from Nature's dissolution, and indeed the rescue of Nature herself from her own negative stage of self-undoing.

At present, accordingly, the task is to put into order the second part of the Diacosmos, —the radiant Diacosmos—in whose domain we place the three Radiants, which are Heat, Light, Electricity. They are sometimes called radiant Energy, or radiant Motion, as if Motion had now become explicit, taking its own form against Matter, and manifesting itself in its own right and in its own medium (Ether). Hitherto Motion as particular has been more or less material, even in the fluids; but now it breaks loose and defies gravity of every kind, radiating under conditions from bodies small and great. It shows itself reacting against Matter, flying away from the same as its oppressor and asserting its freedom. In all this what is Motion trying to do? Evidently to undo Matter and get back to its source. What is this source? Ultimately the All-

Self, from which Nature primordially separated as Motion and as Matter. This striving or aspiration we have always found in Nature and her children; Motion as her earliest child, is here seen struggling to get rid of the grand separation, overcoming Matter as the starting-point and raying forth in every direction toward the All. Radiation may be deemed, therefore, the real appearance of Motion, its veritable phenomenality. What if Motion succeeded in its striving? It would undo itself, having attained its end, which is in its last completion self-hood. Motion strives to be Self, and so seeks to undo its own primal unselving, which gives Nature, the Unself. Thus Motion in its pushing ever beyond and beyond itself shows a sort of aspiration, which in the radiance of light becomes luminous, yea self-luminous, shining forth out of its previous darkness.

Repeatedly we have said that the radiant Diacosmos has as its content the process of the three Radiants, which are to be unfolded in their proper order. These are as follows:

I. *Heat*—the immediate Radiant, essentially molecular in action, radiating itself through the Ether in undulations which are non-luminous.

II. *Light*—the luminous Radiant, dividing within itself and radiating itself as divided, having self-expansion rather than molecular expansion.

III. *Electricity*—the circuit Radiant, self-returning in circuits which are then radiated through the Ether.

Such is a brief preliminary statement of the second stage of the Diacosmos with its three Radiants. Yet all three can be conceived as united in one primordial Radiant, or as the universal diacosmical ray which separates not only into these three forms, but also into an infinite number of rays included in them. Indeed scientists have conceived a kind of scale or key-board of Radiants like that of a piano, with its octaves and separate notes. Heat rays, light rays, electric rays, and also chemical rays, are arranged in one scheme on a scale of 27 octaves, more or less, of which the light-rays form only one octave or one twenty-seventh part. Such is the small range of visible undulations of the Ether in the sum total produced by the Radiants. Such a key-board may be extended to embrace also the vibrations of sound. According to Savart, the limits of audibility lie between 16 vibrations in a second (lowest), and 48,000 vibrations in a second (highest). But the limits of visibility lie between 400 millions millions of vibrations in a second (dull red of the spectrum) to 800 millions millions (the violet of the spectrum). Beyond the violet the invisible (ultra-violet) rays have been discovered, especially through the photographic plate which is far more sensitive than the human eye. A scientist declares that these invisible rays have been detected up to 3,000 millions millions of vibrations. So there is conceived a scale from this number to the lowest

sound of 16 vibrations. What lies between? Much of it is unknown; here indeed is declared to be the enormously large undiscovered country for the coming explorer. Says Lord Kelvin generally of this sphere: "This is an unknown province of science;the investigation of vibrations between those two limits is, perhaps, one of the most promising provinces of science for the future investigator."

Such is pretty nearly the radio-active scale of the whole Diacosmos. The fact is, however, that it can be extended into the Cosmos, in which we have noticed the radial movement produced by the rotation of bodies largest and least, which radiates revolving suns and planets as well as whirling globules of water. The undulation of the diacosmical Radiants may well be deemed to have an analogous character, indeed to be in a line of evolution from their cosmical parallels. Still there is a difference; the one we may call radiant Motion, that of the Radiants proper (diacosmical), the other is radial Motion, the ejecting power of a revolving sphere (cosmical).

Many years ago John Tyndall gave to the public a book entitled *Heat, a Mode of Motion.* The contents were much read, but the title was its best part, veritably a stroke of genius. This title, easily intelligible, was adopted by the public, and became a part of the general consciousness of the time. Heat was defined and correlated for the ordinary man, and rose at once into popularity.

I.

Heat.

So it comes that an axiom of modern Natural Science runs: Heat is a mode of Motion. This expression carries Heat back to the primal start of Nature herself, whose first manifestation was Motion, the Separating. The implication is that there are many modes or forms of Motion of which Heat is but one, occupying one sphere, showing one stage. As we order it here in the great temple of Nature's appearances, it is the first of the three forms of radiation in the second part of the Diacosmos, which we call radiant from the foregoing basic characteristic. Heat is, accordingly a Radiant, though not strictly the luminous one, which is Light.

Heat can be grasped as a form of Motion separating from one material form (say the sun), and entering another material form (solid or fluid) whose molecules it separates and endows with itself (makes them hot). Heat moves from body to body and imparts its own separative character internally. It is a form of Motion assailing Matter and rending the same asunder in its molecular structure, whereby of course the mass is also affected. Heat has the peculiarity of reaching the molecules of a body, which it then disintegrates, pushing these minute particles apart into space. From this point of view it has a negative char-

acter, being directed specially against cohesion, or the unity of body. In such a conception we see Heat to be a great diacosmical energy, a furious one indeed, veritably demonic in its disintegration of the Cosmos.

It is set down in books on Physics that a cubic inch of Matter holds 100,000 trillions of molecules —that being the estimate of Lord Kelvin. A hundred thousand is a good many; but add to it eighteen ciphers more, and the arithmetic soars quite outside of mental grasp. In general, however, we can conceive the extreme divisibility of Matter, to whose minute particles Heat is borne or vibrated by the waves of the subtle fluid Ether, in whose ocean they lie. At once they begin to expand and to drive from within outward; they also become centers of radiating Heat into the environing world; each molecule we may imagine a little sun throwing out its warmth, and thus getting its own again, for originally it was a hot gaseous mote of the Heliosphere, perchance hundreds of millions of years ago.

We may say that Heat assails the *constitution* of the material body, pushing apart its molecular constituents. Chemism on the other hand assails the *composition* of the material body, decomposing it into its atomic elements. Impact assails the *position* of the material body; being molar, it does not properly touch the molecular constitution or the atomic composition of Matter. Still they all

are forms of Motion belaboring Matter, seeking in some way to undo it, but not succeeding. Impact and cosmical Motion generally produce transposition; but Heat and diacosmical Motion (oftener called Energy) produce transformation, along with change of place. Of course the outer molar collision of bodies can generate Heat which causes their inner molecular separation.

In another aspect we can regard Heat as something liberated, set free from its bondage to Matter, against which it reacts. The Cosmos may be deemed its prison, the Diacosmos its freedom. Moreover, it shows this side of its character by raying forth into bodies and unchaining the fixed and fettered molecules there; yea it releases itself bonded in latency to cohesive Matter, and then waves forth from the new center, as already stated. There is a striking analogy between the human mind and the Diacosmos in this tendency to freedom. Periods as well as men become diacosmical, breaking loose from the fixed, the established, the transmitted. The eighteenth Century was noted for its original work in Chemistry and in Physics; it was truly a diacosmical century, expressing itself creatively in Natural Science, which had its counterpart in the political and other revolutions of that time of spiritual upheaval and liberation. Men generally, and specially the scientists, showed a diacosmical consciousness, which worked wonders on certain lines,

though deeply negative in other ways. And that mental movement has by no means yet ended.

We think quantitatively of Heat: it is so much and no more. The earth is supposed to have lost much Heat and is still cooling off; one estimate states that terrestrial Heat is lessening at the rate of one degree in a thousand years. The sun, too, is shrinking with the loss of its Heat radiated forth into the interplanetary, yea into the interstellar spaces; its periphery is declared to be contracting ten inches a year through the dissipation of its expansive power. The solar reservoir is thus losing its contents. But we may suppose that what is lost in one part of the universe is gained in another part, for how can it run away? How can anything get outside of the universe—outside of that of which there is no outside? We may also think that the All-Self as separating or as Nature-making is ever active, has to be so in order to be itself. Hence its Motion is somewhere in the great Totality, and simply cannot vanish or even grow less. The so-called conservation of Energy, or better, of Motion implies this. The quantity is the same, though everywhere undergoing a state of change (see preceding p. 82).

Heat, as here specially conceived, has its limits against Light and also against Electricity and Chemism. Still it is to be remembered that all these different stages have Heat behind them and as it were embracing them. Heat is therefore a kind

of universal Radiant; we may regard it as the original diacosmical ray, from which the other Radiants evolve, out of which they divide and spread over the before-mentioned scale or common spectrum of radiation. Besides this universal phase of itself, Heat is also particular, distinguished specially from the other Radiants, having its own sphere and its own distinctive place (or octaves) on the total key-board of radiation. In the Fluids we may deem Heat to be more or less implicit, while as the first Radiant it becomes explicit, being felt and measured in its own right.

It was Sir Humphrey Davy who conceived the brilliant experiment of liquefying ice by rubbing two pieces of it together in an ice-cold room and thus generating Heat enough to melt them. Previously Heat had been by most scientists regarded as a material element, a subtle imponderable fluid which stimulated the sensation of warmth, and produced the well-known thermal effects. But it could evidently be produced by mechanical friction which set the molecules of the body in motion. This new sort of motion which was evidently radiated in vibrations, was indeed "a mode of Motion," or more closely, a form of radiant Motion, truly a diacosmical Radiant, the first the most immediate, and the most common one of them all.

In organizing the subject of Heat, we shall look at it, first, as it is in itself; secondly, in its separative or expanding effects upon bodies; thirdly,

in its sources or generation, whereby it is seen to return and to produce its starting-point.

I. Heat, as Such. It is often said that we cannot know what anything is in itself (*das Ding an sich*), but only its phenomenal phase. Nature undoubtedly appears, but she cannot help showing what she is in her appearance. If she could say one thing and be another, it were hardly worth while to interrogate her about herself. Experiment is Nature's cross-examination, and science takes for granted that she tells the truth where her answer is fully given and fairly understood. It is an easy experiment which shows that Heat is transmitted in continuous lines; a screen interposed between you and the fire cuts off the warmth. It passes through a medium which is perchance the air directly before us; but if we take away the air we find that a vacuum is no obstruction to Heat. Moreover, it rays out from the sun through the cosmical spaces in which there is no air like ours. Still it has its medium, the fluid in which it is propagated, the Ether, which, being without strict cohesion and gravity, is infinitely responsive to the impress of the ever-radiating heat-wave. The hot body, like the sun, sends off Heat which is a form of Motion; accordingly it must send off its own Motion, separating the same from itself; indeed just this power of self-separation is what the sun primarily emits in Heat. Such is thermal radiation, for this separative char-

acter is what the central luminary projects i.. Heat. No wonder, then, that Heat is not only expansive in itself, but also expands everything else.

1. *The Thermal Ray.* The first conception under radiant Heat is that it moves in rays analogous to those of Light. Moreover this ray of Heat is not hot in itself; it can pass through the air without heating it, or without heating it much. If it weie a perfect medium it would not be heated at all, being a pure transmitter of thermal energy. Not till the ray is absorbed by a body and re-radiated from the same, is Heat manifested. Apparently not till radiant Heat finds the material molecules and is set to work, does it show itself. It must be disintegrating Matter in order to reveal its character. The simple transmission of Heat through the Ether does not call it out, for the medium offers no resistance. A body does not need to burn or be incandescent in order to emit Heat, a bottle of hot water radiates Heat without combustion. In like manner a ray of light is not luminous in itself, or rather in its etheric medium.

(*a*) The radiation of Heat takes place in all directions from hot bodies. If we could see the rays, they would form a gradually diminishing sphere around their center, as do those of Light. Not alone the sun but every piece of Matter is such a center of heat-radiation and is surrounded by a sphere of heat-rays, pushing outward against

cohesion, against gravity, against Matter itself. This radiation is likewise conceived to be rectilinear, making straight for the circumference of the heat-sphere like so many radii of a circle.

(*b*) It is evident that these heat-spheres must intersect, each hot body great and small being the center of one such sphere. Moreover some bodies are hotter than others through various causes; the result is an ever active exchange of temperatures. Thus there is on our earth a rolling ocean of heat-waves which have a tendency to seek a certain level or equilibrium of temperature. Each cold body strives to get its share from the great totality of Heat, which is made up from the radiation of hot bodies. It has its resemblance to the world of traffic from which each person has to supply his wants, but to which he must also give his part.

It is to be observed that these fluctuations of heat-waves prescribe the limits on our earth to conditions of life. Between the freezing point and boiling point of water—one hundred degrees Centigrade—man has his terrestrial existence; not much below or above these two points can he hold out. Such is the limited temperature in which man has so far evolved. Of course heat reaches far above and cold far below these two boundaries; on other worlds there must be a new adjustment, if they support life as we know it.

(*c*) Radiant Heat moves through space at a certain rate of diminution; the farther it passes from

its heated surface, the less strong is the heat-wave. The law is: the intensity of the radiation varies inversely as the square of the distance. At one foot from its source radiant Heat will be four times greater than at two feet. As the periphery of the heat-sphere is extended there is a greater surface to be covered by the heat-ray. This law of radiation calls up the similar law of gravitation, which thus seems to ray out (possibly through the Ether) and draw Matter together. But radiant Heat will expand and separate Matter, and so seems the counterpart of attraction. But their powers are quite the same: each diminishes equally as it recedes from its center.

2. *The Thermal Ray impinged.* The impact of the thermal Ray upon bodies in its path brings out decisive characteristics of it. The collision with Matter makes it show its true colors, so to speak; as merely radiating unopposed into space, it is brought to no pivotal test. What, then, will the thermal Ray or the rolling heat-wave do when it finds its way barred by a piece of Matter which may be deemed its enemy? One thing is certain: a fight will take place which is indeed but another phase of the millionfold struggle between Motion and Matter running through all Nature. Also the body struck will show its character in response. It may reflect the Ray immediately, flinging the same back: it may absorb the same and then emit the acquired Heat anew in all directions; or it

may transmit the same through its own substance.

(*a*) The impinging ray of Heat falling upon a polished surface is largely reflected and the angle of incidence is equal to the angle of reflection. In concave mirrors Heat can be focused so as to set fire to gun-cotton. By a concave mirror with an aperture of six feet silver has been melted. Buffon, by an arrangement of 168 mirrors ignited tarred wood at a distance of 210 feet, repeating what Archimedes is said to have done to the Roman fleet besieging Syracuse. Different metals at the height of their polish show different powers of reflection. Brass is the best reflector; glass has only one-tenth as much. Radiant Heat glances off almost entire from a bright brazen surface. We have to think that the etheric medium when thermal finds it difficult to enter the molecular structure of brass.

(*b*) We put together the absorption and the emission of Heat, for the law is that bodies which absorb Heat best emit it best. Lampblack and water are set down highest in the list of thermal absorbers and emitters; on the other hand they are the poorest reflectors. When the heat-ray is reflected from a bright metallic surface, it is refused admittance to the inner molecules of the substance; but it is taken into them by absorption, and draws them apart, when it is again rayed forth. Likewise the impinging Ray is absorbed

most completely if it strikes at right angles; the greater the inclination from the perpendicular, the less the power of absorption in the same material; striking sidewise the heat-ray glides off in part.

(*c*) Heat is also transmitted through certain bodies with varying degrees of completeness. Such bodies have received a special name in view of this property: they are called diathermanous. Rock-salt has the name of being the most perfetly diathermanous substance. not pure glass, which is most transmissive to Light (or transparent) but not to Heat. The opposite quality is called athermanous (seen in metals) and corresponds to opacity in the realm of Light. The curious fact also is noteworthy that the same body, such as glass transmits heat differently according to the different sources of its emission. The heat of the sun, the heat of a burning terrestrial body, and the heat of a water-bottle (or the so-called Leslie's cube) have not a like capacity for transmitting themselves through a substance, even when the degree of Heat is the same. Thus the heat-ray itself seems to shift about into a variety of characters, according to its origin. The medium (Ether) bearing the thermal Radiant is diversely determined by the molecular constitution of diverse bodies; likewise the thermal Radiant itself is diversely transmissible.

Many are the analogies between Light and Heat.

We are naturally led to ask whether the thermal Ray has anything to correspond to divisions of the spectrum in Light. Melloni has worked in this field and finds different phases or stages of the thermal Ray, seemingly according to their different refrangibility. These he calls colors of Heat by analogy to the spectrum. He employed various sources of Heat, as the sun, hot water, lamp-flame of different substances, heated platinum wire; these diverse rays he passed through various substances variously diathermanous, as glass, rock-salt, alum. But a heat spectrum like the light-spectrum has hardly yet been constructed, and substances otherwise unknown but emitting Heat, cannot yet be detected by the character of their thermal Rays. Possibly that will come next, and we shall have a thermoscope for analyzing the heat-rays from the sun and stars.

The transmission of Heat through a diathermanous body is seen in the lens which focuses Light along with Heat. This is the well-known burning-glass which indicates that Heat undergoes refraction as well as Light.

Such are the forms of the heat-ray impinged upon bodies: it is reflected, it is absorbed and then emitted, it is transmitted. These may be deemed its varied transformations by the substance, which is next to take it up and to transport it as it is in itself.

3. *The Thermal Ray transported (conducted).*

This means that Heat is borne from molecule to molecule of some substance which carries it on. It is different from transmission in which the thermal Ray passes through and out of the molecular structure of a body, leaving the latter quite as it was. The radiation now involves the material and is seemingly conveyed by it. Various bodies are variously gifted with this power of transporting Heat, or with conduction as it is usually called. Metals are good conductors of Heat; it seems to be carried at once through the cohesive molecules; an iron rod heated at one end is soon hot at the other. Wood is a poor conductor, so are organic substances generally. Nature is made up of a vast and varied conductivity; bodies show their individuality in this way as well as in reflection or transmission. Rock-salt is not a good transporter though the best transmitter of Heat. Brass if polished is a good reflector, but can be made a good conductor of Heat. The transportation of Heat through bodies is chiefly determined by their molecular constitution, that is, according as they are solids, liquids, or gases.

In diathermanous bodies Heat seems largely inter-molecular in its activity, hardly getting inside the molecules; while in good conductors it becomes intra-molecular, so that the structure of the body is heated and expanded.

(*a*) The difference in the Heat-transporting capacity of solids is very great. Glass is as rigid

and cohesive in its way as iron; yet the one refuses almost absolutely to carry Heat, while the other is quite eager for it. From a window-pane Heat glances off, and it remains cold in a warm room; nor will it transport Heat from corner to corner of itself. Cotton and wool are bad conductors of Heat, and upon this quality depends one of their uses for clothing. A woolen garment is not strictly warm in itself; it simply does not carry off the warmth of the human body. Every material object has its attitude toward the transportation of Heat through its varied molecular structure; in this way it shows individuality as well as in many other ways.

(*b*) Liquids have mobility of particles or of molecules as distinct from the cohesion of solids. As Heat expands bodies through the molecules, a liquid might seem more amenable to it than a solid. But liquids are on the whole bad conductors of Heat, the chief exception being mercury, which, however, is a metal and partakes of metallic conductivity. Water can be boiled in the upper end of a test-tube while a piece of ice remains unmelted at the other end. This means that the Heat is not conducted downwards. But if the water be boiled in the lower end of a test-tube, the heated molecules of the liquid will rise to the top, from which the cold molecules will drop to the bottom, become heated and rise in their turn, making a continual round. This is called convec-

tion; liquids are heated by convection; Heat is conveyed throughout the mass by the foregoing molecular whirl. Of course the first Heat is imparted to the water through the sides of the vessel by a slight conduction, which then turns to convection. In conduction the molecules are conceived to be fixed or rigid, but in convection they are mobile and sent upward as carriers, and then come back when cooled and contracted.

(*c*) Gases are composed of molecules not only mobile but expansible; thus they are exceedingly responsive to Heat. In this capacity to expand they are notably different from water, for instance. At the same time they are very bad conductors of Heat, though there is a difference in their conductive power, oxygen being nearly twice as good a conductor as hydrogen (according to the Smithsonian tables). On the whole, substances with greatest convectivity have least conductivity, and vice versa; silver and hydrogen seem to be the extremes on each side. The cohesive and confined molecules of the metal as well as the free and elastic molecules of the gas transport Heat rapidly, each in its own way. The thermal Radiant with its medium seems to move unobstructed through the consecutive molecules of a silver wire, while it is, as it were, picked up and carried by the gaseous molecule. Liquids on the whole share in both conduction and convection.

We have now looked at Heat as such, in and

by itself, as far as this was possible. We have seen the thermal Ray's first etheric radiation out of its center in all directions; then we have watched it impinging upon bodies, and the consequent developments of it thereby; finally we have observed its varied transference from place to place by means of bodies. In this treatment the stress so far has been upon the action of the Heat in relation to bodies. But now we shall consider rather the action of bodies as determined by Heat; our eye will be chiefly upon the object affected by Heat.

II. Heat as the Expander of Matter. Already this quality of Heat has had to be repeatedly noted in various connections; at present we seek to make it the center of observation. Heat is primarily a separator, belonging to the separative stage of the Diacosmos, which is itself Nature in her divisive mood. The expansive power of Heat is a moving outward and over the limit—a molecular separation of bodies. In the transference of the thermal Ray we have just seen Heat transported by Matter; but now we are to witness Matter transported by Heat, borne asunder and transformed. Hitherto the thermal Radiant has radiated itself mainly upon and through Matter; next it must radiate Matter too in its waves.

1. *Cohesive Molecularity Expanded.* So we designate the first effect of Heat under the present head: it assails the solid and drives its molecules

asunder. This force of expansion in the solid is very great and has many applications in the arts. Also its counterpart, the contraction of a solid after heating, is used in many a mechanical dexterity. The engineer in his iron structures, such as bridges, railroad tracks and high buildings, has always to reckon with the metallic expansion and contraction through the increase and diminution of Heat. The presence and absence of the sun are marked more or less distinctly on the faces of all substances.

(*a*) As most structures of importance involve the line more than the solid, linear expansion has been specially studied and put into tabular form by physicists. The need of knowing the relative expansibility of metals had been long felt, but Lavoisier and Laplace toward the close of the 18th century, seem to have been the first who made careful experiments and constructed what is known as a table of linear co-efficients. A bar of the substance was put into melting ice and then into boiling water, its increase of length being carefully measured. Platinum was found to be the least expansible metal, and zinc the most expansible, through the given 180 degrees Fahrenheit. Alloys of metals seem to have the power of counteracting each other's expansibility. A French physicist has discovered a combination of steel and nickel (a little over one-third nickel) which expands less than one part in a million, thus having a linear

co-efficient less than one-eighth of that of platinum, (which is tabulated at 1-120000ths) The name of this interesting alloy is *invar* from its invariability in all temperatures. The gridiron pendulum, composed of steel and brass rods so arranged that the expansibility of the steel downwards is counteracted by that of the brass upwards, is a contrivance to make the clock keep invariable time through heat and cold. India-rubber seems to form a curious exception among solids: a strong tube of this material heated inside with steam, will actually contract and draw up a heavy weight attached to the lower end. This is the opposite to what we have observed in metals and other substances, which let out when hot and draw up when cold. Now the fundamental property of rubber is just this expansibility in the form of elasticity. What it does of itself it resists when done by Heat, which in this case counteracts native expansibility. Or we may say that Heat, separative in character, is brought to assail and overcome separation in one instance at least. This exception among solids resembles the exception among liquids in case of water.

(*b*) Heat, the expander, has the power of transforming solids. Not only does it cause a linear and also a cubical expansion of bodies, but also it changes their form, and with it their properties to a certain extent. The melting point of metals varies much, and is of greatest importance in

manufacturing, since they can be shaped according to their fusibility. Mercury is the most fusible of metals, becoming solid at 38 degrees below zero (Fahrenheit), while gold runs up nearly to 2,000 degrees (F.). Platinum's point of fusing is more than fifty per cent higher than that of gold, while rhodium is about twice as high and iridium still higher. Molecular cohesion thus shows many stages of resistance to Heat, asserting the forms of things against its assault. Alloys are said to be more fusible than the metals composing them—seemingly a mark of inner uncongeniality. Per contra liquids are solidified by diminution of Heat, whereof examples are seen in the freezing of mercury and of water. Finally Heat will not only liquify but vaporize metals and other solids. The surface of the sun supposed to be 14,000 or 15,000 degrees Fahrenheit, is the scene of a vast vaporization of metals. On the earth Heat has great possibilities before it both through increase and diminution—we have probably not yet artificially produced its highest and lowest point.

(*c*) The expansive power of Heat has been put to use, or has been made to work. How can this power be measured and thus applied? A pound raised a foot requires a certain quantity of energy or Heat—such a unit of measure is called a foot-pound. To lift a pound weight 772 feet high, the Heat consumed would raise a pound of water one degree (say from a temperature of 60 to 61 de-

grees). This is the unit of measure (called the mechanical equivalent of Heat); so much work can be done by so much Heat measured by its capacity of warming so much water (the typical liquid) one degree. The manifold power of Heat required to expand many millions of liquid molecules is unified in one power which acts mechanically. Molecular energy is equilibrated with mechanical energy. A foot-pound is constant, is a standard—so much thermal energy cut off as a measure. Two different resistances there are, that of the liquid and that of the solid; a quantum of one is made to measure the other.

This discovery is justly regarded as one of the most important in modern science. The credit seems to belong about equally to two men, the German Mayer and the Englishman Joule. The practical value of this mechanical equivalent of Heat is of the greatest in our industrial world. Through it is calculated the amount of Heat (or Energy) which, generated from fuel and mediated by machinery, will do a given quantity of work.

2. *Liquid Molecularity Expanded.* Or as it is usually called, the expansion of liquids by Heat. The molecule, separated from but indifferent to its neighbor, is mobile, easily moved about by being heated. This is most commonly seen in the ebullition of water. Less regular than solids is the expansion of liquids, and is not linear (unless confined, as mercury in a tube) on account of their

uncohesive nature, but is cubical or by volume. The liquid has to be held in a vessel which also expands. Heat seems to work both between the molecules and also inside of them; it is both intermolecular and intra-molecular in its action.

(*a*) The Liquid in its immediate form has been already considered quite fully (see preceding p. 373 et seq). It may be here stated that liquidity comes originally from Heat. Liquid water is converted into a vapor by an increase of Heat; and into a solid by a diminution of Heat. The liquid molecules are such through Heat.

(*b*) Heat in general divides at a certain line into hot and cold, determined by human sensation. Still such a distinction is not simply subjective; Heat has its positive and negative sides, both of which affect the expansion of bodies, and especially of Liquids. Ordinary heat and cold are measured by a column of mercury in the thermometer; but far higher and lower temperatures have also been measured by various contrivances.

(*c*) Two Liquids (or other substances) get hot differently with the same amount of Heat, for instance water and mercury. Hence the amount of one Liquid heated one degree can be taken as the unit of measure, and we have what is known as Specific Heat. The quantity of Heat necessary to raise one pound of water through one degree has been taken as the thermal unit of Liquids, and a table of comparative Specific Heats constructed. A

striking peculiarity of water is that it has a high Specific Heat. Its molecules respond more intensely to the expansive power of Heat against gravitation than most substances. Water expands doubly through heat and through cold; as already noted it expands on both sides of 39 degrees Fahrenheit (4 degrees Centigrade), at a higher and a lower temperature.

3. *Gaseous Molecularity Expanded.* Or the expansion of gas, vapor, air. The molecules are now repellent, and Heat makes them more repellent. Hence expansibility through Heat becomes a decided property of the gaseous sphere. Moreover great force is engendered through expansion of vapor, which, being harnessed to a machine, becomes of enormous service, as the steam engine.

A fundamental fact about the expansion of Gases is that they all expand equally or nearly so at the same degree of Heat. All Gases then expand for one degree Centigrade, 367 parts in 100,000; or to 273 parts one part is added through expansion, caused by a degree of Heat (Ganot). This sameness is broken when it comes to density, wherein Gases differ much. If air is one, hydrogen is one-fourteenth as dense, while chlorine is nearly two and a half times as dense, or has so much greater specific gravity. So in Gases weight is very different while expansibility is the same practically.

(*a*) Liquids and solids have a tendency to turn to Gases in various degrees by means of Heat,

which is always present and making itself valid. This is known in general as vaporization, and consumes Heat, which makes the indifferent molecules of the Liquid self-repellent and in so far drives them counter to gravitation. But the rigid solid, even the metals can be vaporized by a sufficient degree of Heat. In the Sun the spectroscope shows metallic vapors; indeed in the hottest stars there would seem to be a primordial vapor out of which the chemical elements have evolved by a process of cooling. The nebulæ are generally supposed to be constituted of hot, self-luminous vapor, which represents a very early stage of world-making. If this be so, the tendency to vaporization of substances at ordinary temperatures is a kind of reversion to their beginning; they are still seeking to go back and complete the round.

(*b*) The counterpart to vaporization is liquifaction, and then solidification. This is accomplished generally by the negative of Heat, named cold, which counteracts expansion by contraction, and seems to drive out the inter-molecular and intra-molecular enemy of itself. Here, then, the mighty struggle between the hot and the cold (of which the ancient philosophers made so much) manifests itself in a great variety of forms. Indeed Rumford claimed that there were cold-rays which could be reflected and focused like heat-rays. But all scientists say that cold is generated in a substance passing from the liquid to the gaseous state while

heat is generated by the reverse; that is, the latter is released and dissipated. In this interplay between cold and heat the physical universe is always moving and as it were wrestling; the molecular structure is the arena of conflict, changing continually in a cycle of gas, liquid and solid, receiving and expelling Heat. Especially on our earth does this give rise to the meteorological process.

(*c*) The measure of Heat in all its various relations and applications has been diligently wrought out by scientists, doubtless on account of its practical importance. To find the unit by which energy of expansion and contraction may be measured is the object. Torricelli made the start when he balanced the pressure of the atmosphere against so much mercury; Pascal did the same thing with water. Then we may take Boyle's (Mariotte's) law that the volume a gas is inversely as the pressure; and hence the product of the two (volume and pressure) is a constant (not quite, but near enough for practical purposes). Next comes Gay-Lussac's law that all Gases expand equally with equal increments of Heat. Regnault finally (after Dalton, Arago and others) measured the pressure of aqueous vapor at various degrees above and below the boiling point and constructed a table of such pressures. Thus the expansion of gaseous molecules by Heat has been measured, as well as the expansion of solid and liquid molecules; wherewith this part of the subject comes to an end.

III. Heat Generated. It is pertinent to inquire after the origin of Heat. Already it has been pronounced to be a mode or form of Motion, which carries it back to the first manifestation of Nature. More intermediately Heat has many sources from which it can be produced. If the molecular structure of the solid be assailed by friction, by pressure or percussion, Heat will arise. We have already noted that two pieces of ice rubbed together in a vacuum below zero have been melted by the friction. Chemical separation of atoms, as in combustion, produces Heat. When the constitution of bodies, be it molecular or atomic, is disturbed, Heat is given off. Still such Heat seems to be already existent, though stored up and latent, so we continue to ask whence came it originally. First, however, we may briefly classify its main sources and then measure it.

1. *Primal Sources.* These are essentially cosmical and are relatively persistent. We may here first regard the *Earth's Heat*, which below the depth of 100 feet is said to have an invariable temperature of 52 degrees. Before that depth is reached, there is a gradual increase from the surface. Still after an invariable belt within the Earth, the Heat is supposed to increase till the center is of molten material, somewhat as the whole Earth was when ejected from the Sun. At that time its axial rotation was much faster than at present. The *Sun's Heat* comes externally and its influence

is supposed to reach some distance below the terrestrial surface, which lies between two primal (or cosmical) sources of Heat, and obtains thereby its thermal variation. Both these sources of Heat were once united in the *Heat of the Heliosphere*, which was itself probably derived from a still larger nebula.

2. *Secondary Sources.* Any assault upon the molecular structure of a substance in one way or other calls forth Heat. Such an assault can take place from the outside, as friction, percussion, pressure; this may be called a *mechanical* source of Heat. But the assault may be from the inside, upon the molecule itself directly; so electricity (and probably light) generates Heat—this may be called a *physical* source of Heat. Finally there is the *chemical* source of Heat, manifested in the decomposition of substances, especially in combustion.

It is evident that in all these cases Heat is produced in an intermittent finite manner, arising and vanishing according to the conditions. Thus it goes a certain round in a small way, which round is also seen in the sun and stars which increase and decline in Heat with the æons.

3. *Heat Measured.* If Heat be a form of motion radiating through the Ether, it must have its motion measured; it moves through so much space in so much time. Its *constant* is its velocity, 186,000 miles per second; this velocity it has

in common with the other radiants, Light and Electricity. Its radiation becomes visible in the red, which produces about 34,000 waves to the inch; below the red in the universal spectrum lies the region of dark heat-waves (seven octaves) or of Heat proper as distinct from the other Radiants. This is its *specific measure* or differential, which being multiplied into the constant or velocity per second, gives about 400 million millions of etheric undulations every second to produce the sensation of Heat which is next to the color red. This tells the *number of heat-waves* at their greatest.

II.

Light.

According to the present way of ordering Nature, Light is one of the three Radiants of the Diacosmos. Moreover it is the second one and shows the second stage or phase of radiation, of which Heat is the first and Electricity the third. It is important to note the place of Light, about which physicists have been seemingly indifferent; sometimes they put it first in their books and sometimes third. But it is properly the second stage, and that not by accident; it forms with Heat and Electricity, the process of the three diacosmical Radiants, which has its deepest roots not merely in the realm ot Nature, but of Mind, constituting what in this treatise is called a psychosis.

We are, then, to think Light as separative, but in its own way, for we have found many separations in Nature, indeed Nature herself is primordially a separation. Light we call luminous, yea self-luminous; it has the peculiar power of manifesting itself while it manifests other things. It divides within and ejects itself in order to be itself. This inner self-division and self-radiation make the basic character of Light; it is the separative Radiant of the three, self-dividing and self-reflecting; not only does it radiate itself outward like Heat, but also radiates itself radiating; it is an undulation indeed, yet likewise it undulates itself undulating. Light reveals, reveals the world, but at the same time it is the self-revealer of the Diacosmos. This twofold character of Light is fundamental; thus it is truly the Light of Nature, her act of self-revelation.

The analogy between Light and Mind or Ego has always been felt by man, and has found expression probably in every language. This inner diremption of Light, though a physical phenomenon, suggests the inner diremption of the Self in the act of consciousness. For the Ego also divides within and thus manifests itself to itself; it becomes aware of the world along with its own self-awareness. In fact we may deem Light the central form in the total evolution of Nature, which is now irradiated by it on all sides. Light is the center of the Radiants of the Diacosmos, of the

whole physical Order. In it Nature gets a kind of outer self-consciousness which illuminates both her and itself. Metaphorically Light is still called Intelligence, and may have evolved it through the æons. Light indeed we may deem Nature's primordial Ego, individualized millionfold in the sun and stars.

But, coming back from these far-off reaches of thought, we have to connect Light directly with its antecedent, Heat, from which it separates first, which separation is always going on. Heat must be present with and in Light that it be separated from the same. Quantitatively the separation of Light from Heat is marked on the spectrum, whose red ray is set down as having 400 to 450 millions millions of vibrations of the Ether per second. Below the red ray is the heat ray, non-luminous, unmanifested, through not having enough vibrations. The qualitative difference seems very sudden and striking: Heat has no power to radiate itself radiating, though it radiates itself. The change involves the triple capacity of Light for manifestation: (1) it manifests its source; (2) it manifests itself; (3) it manifests its opposite which is non-luminous Matter.

Light like Heat is a mode or form of Motion, which connects it with the starting-point of all Nature. We may further consider Light to be a form of Motion separating from a form of Matter and showing both forms, namely itself and Matter.

Also we may deem Light (like Heat) as a liberation—liberation of a force or energy which rushes forth outward and spends itself somewhere in the Cosmos. It is a liberated Motion, previously tied to Matter or imprisoned in the same; we may mythologize it as an Ariel pegged in a cloven pine by some dark agency and then set free by a Prospero. So it is a Radiant which not only radiates itself, but at the same time radiates itself radiating, illuminates itself illuminating, and hence is self-luminous.

Light stands in most intimate relation to human vision, but it is not merely subjective, as has been thought sometimes. It is objective also, existent in the universe, indeed a necessary part thereof. Light we have deemed a kind of Self in Nature, dividing within itself and revealing itself to itself in the course of its own evolution. The inherent movement and necessity of Nature evolved Light long before there was any eye to see it; the sun shone and the stars sparkled in and of themselves, independent of the sense of sight, unless we regard the sun and stars as the actual eyes of the Cosmos looking at itself. It has been held that Light evolved the eye of animate creatures for its own behoof, in order to see itself so to speak, for it has no complete self-reflection except through that wonderful union of lens and mirror called the eye. The Radiant, Light, though it radiates itself as radiating, cannot completely turn about and view

itself unless by means of the sense of sight. Light may be said, therefore, to find its real fulfilment in the living eye, which radiates it back to its source or to itself. The candle before the mirror can image itself but cannot see itself; it can reflect itself outwardly but cannot reflect its own self-reflection, though we may conceive it to be striving after such a power, as all Nature shows a similar aspiration. Still Light is not yet subjective, though traveling thitherward and dimly foreshadowing the far-off Ego coming on, whose deepest trait is to be self-seeing. Even the living eye cannot yet see itself without an outer reflector, but it can see Light reflected which cannot yet see, though hurrying to get eyesight with all the speed of its radiation.

Coming back to Heat, we may again glance at Light rising out of it and illuminating it, for it cannot shine and show itself. We might feel Heat, but we could not know whence it came without Light, which therein reveals also its own source. Heat is, accordingly, immediate to sensation, coming in the dark, unless accompanied by Light, which performs again its double task of manifesting its other and itself at the same time. Heat assails Cohesion or the molecular oneness of body, and tears it to pieces often with furious energy. In this respect Light is different, it hardly opposes Cohesion, but rebounds from it, turning back upon itself without affecting seriously the material body

which it meets. Its energy seems to be chiefly spent in its own self-separating act which, as we have seen, is the source of its luminosity. It rays itself out instead of raying out and expanding the struck body, as does Heat. Light as radiant is indeed the opposite of Cohesion, yet not the vicious destructive foe of it, rending it asunder: rather does it quietly manifest and acknowledge the cohesive body in accord with its enlightening character. On the contrary Heat has an angry, dark, demonic strain in comparison with Light, and carries its negation quite to the point of self-negation; passing a certain line of intensity it passes from darkness to luminosity, from expanding a body to expanding itself, radiating anew its own radiation and so reaching manifestation out of its previous unmanifested and unmanifesting state. Undoubtedly Heat and Light are usually found together, but there can be Heat without Light, and Light without Heat as in phosphorescence. Both are Radiants, but with different endowments; Heat radiates itself, but must rise to radiate itself radiating in order to become Light. When it divides itself within and projects outward this act of self-division, it shows itself; it radiates itself inwardly but at the same time throws out this self-radiation. From this point of view Heat may be deemed implicit Light, potential Light not yet shining, not yet born but struggling for birth, for manifestation. Light like Heat is a form of Mo-

tion; it is Motion revealing itself in its own movement; without Light Motion could not show itself, could not be seen. So we may say that in Light Motion reaches the stage of self-illumination, Motion manifests Motion.

Light, like all the Radiants, rays out in opposition to gravitation, and thus shows that it belongs to the Diacosmos generally. At the same time it cannot be said to assail the unity of bodies; it is not actively negative to the attraction of the Cosmos, but rather reveals it to itself, not merely to our vision. Without Light the gravitation everywhere so dominant in the physical universe would not be manifested, it would remain an occult power which had never come to Light. No law of gravitation, even if it dumbly existed, could show itself really, for its Motion would have to stay in the dark. Motion itself must unfold to self-manifestation in Light, which is one of Motion's forms or stages for showing all its other forms or stages. Whether gravitation is or is not an *actio in distans* has been much discussed; for instance does the sun exert its power of attraction upon the earth at a distance without the interposition of any medium of impact? At any rate the sun radiates Light into the distance counter to gravitation, doubtless through a luminiferous Ether, and thus illuminates attraction. Does Light fill Space? We may say that it reveals Space, for without it Space would be a chaotic, dark extension to us, and perchance

to itself. Light manifests what fills Space and the limits thereof; it is a shining omnipresence but without body, indeed bounded by body; it is pure manifestation of Nature, not assailing, not excluding, not resisting, completely penetrable in contrast to Matter. It is just individual enough to show all individuality, just corporeal enough to manifest all body, just material enough to reveal Matter. It radiates not merely itself but its own self-separation (or self-radiation) and thus shines, or has the luminous property by which it not only manifests itself but also its own self-manifestion.

So we attempt to seize the immanent or psychic character of Light as distinguished from its phenomenal side with which the scientist specially deals. We seek to assign Light to its place in the universe, to see where it belongs in the universal order, and to express its significance in some formula or category, which may hint its function in the grand evolution of the All. At the same time Light has its own individual properties and characteristics which are to be investigated and ordered.

Accordingly we shall first consider Light as it is in itself physically; then we shall look at it as separated in manifold ways; finally we shall touch upon it in its generation. In this brief account many details will have to be omitted, since Light has become a vast theme upon which alone big volumes are written.

I. LIGHT IN ITSELF. Already we have sought

to give some idea of Light as a Radiant self-luminous, borne in undulatory vibrations through a medium usually called the luminiferous Ether. Light is therefore regarded as a force working upon a subtle fluid, infinitely plastic and responsive to its movement. In the history of optics two theories of Light have held sway. The corpuscular theory maintains that the luminous body emits very small particles which strike the eye and stimulate it to vision. The undulatory theory holds that the luminous body starts vibrations in the Ether, which bears them by undulations in all directions. The great supporter of the former was Newton; the latter was enunciated by Huyghens, advocated by Young, but vindicated and confirmed chiefly by Fresnel.

1. *The Luminous Ray.* Light is conceived to be propagated in lines, each of which is called a Ray, or a pencil of Light when several Rays are put into a kind of bundle. This conception is useful for isolating a small line of Light and passing it through an aperture for purposes of investigation. The rest of the Rays being stopped by an opaque body produce the shadow which has an important part in the phenomena of Light, one instance being the eclipse of heavenly bodies.

(*a*) Radiation of Light from a luminous body goes out in all directions, and in straight lines. Thus it forms a kind of sphere with brilliancy diminishing from the center. We must suppose that

each ray sends off new shoots at every point and so keeps on occupying space, the whole forming a spherical brush of luminosity. Thus Light spreads out and expands itself, but does not expand bodies which it encounters, as does Heat. The luminous ray keeps forking indefinitely as it darts out spaceward. It naturally makes angles, with its two radiating sides, to which the third is added forming a triangle. This triangulation of Light is what makes it measurable, and was strikingly employed (first by Roemer) for measuring the velocity of Light.

(*b*) Such radiospheres of Light from every uminous center, great and small, necessarily intersect and produce in these conjoined parts an increase of luminosity. In this case Light does not obstruct Light, but aids its own. Under ordinary circumstances there is no impartation of Light to bodies in its field; they do not get luminous as they get hot; their molecular structure is not assailed and expanded by Light as it is by Heat.

(*c*) The radiation of Light grows less strong as it sweeps outward from its center. This diminution proceeds according to the well-known law: the intensity of the radiation varies inversely as the square of the distances. We have found this same Law in Heat and Sound, and also in Gravitation. The ground of it seems to be manifested in Light, whose rays we have seen branching at every point as they move outward and thus be-

coming quantitatively lessened. Moreover these branches shoot out not merely in a plane, but in all directions, forming a sphere of dispersed Light, which thus diminishes not simply according to the distance but according to the square of the distance, being spread over so much surface. This reason one thinks of transferring to the previous cases of the same sort—Heat, Sound, and possibly Gravitation. The force of all of them moves outward, not on lines in same plane, but by squares embracing more and more space. This fact becomes luminous in Light, the revealer; but in the other instances there is no self-manifestation. Light may thus be said to throw its illumination back upon its dark predecessors obeying the same law.

2. *The Luminous Ray Impinged.* Light in its radiation strikes upon the surface of bodies. The result is a collision but not very serious; Light is not a fierce fighter like Heat; it reveals but hardly assails its opponent. Thus the impact brings out the character of this luminous Radiant in various ways. Here especially do we observe in Light a kind of peaceful, contemplative mood; literally it reflects upon an object, and reveals itself in such reflection; its function is not to disintegrate the antagonist but to show him as limited, as occupying so much space at a certain point.

(*a*) The reflection of Light follows in general the same Law as Heat and Sound. Striking on a

surface the light-ray is reflected and comes to the eye returning upon itself and thus gets manifested, visible. It is said that the light of the Sun traversing the interplanetary spaces is quite dark, unrevealed, till it strikes the earth's air and is reflected. Light remains more or less implicit till made explicit by reflection.

(*b*) Not all the light-rays are reflected from bodies, some are absorbed. These rays seemingly vanish, we do not hear of latent Light, though it may in a sense exist. The combustion of coal or wood produces Light which was once stored up like Heat. On the other hand certain bodies emit Light without incandescence or combustion, as is seen in phosphorescence and fluorescence.

(*c*) Transmitted Light is observed in a class of objects known as transparent and translucent. The property of transparency has a great field in glass with its many uses. The window pane which lets Light into a room, without allowing Heat to escape, or the rain enter, has a very important place in human development. Heat which assails and separates the molecular structure discovers the hard glass to be very refractory and is thrown off; but Light which is inclined to leave the molecules alone is congenial to glass, which finds its transparent character manifested only through Light. Heat if transmitted through glass tells nothing of its transparency which is its true character.

3. *The Luminous Ray Transferred.* Conduc-

tivity of bodies has a weighty part in the treatment of the Heat whieh can be transported from molecule to molecule. Of course Light cannot have much to do with such a property, as it hardly affects molecular structure. Light can manifest cohesion in a body, but hardly breaks into it or breaks it up. Solids, liquids, gases, can not strictly be said to carry Light or to conduct it, even if they transmit it or rather allow it to be transmitted. Here then is a striking difference between Light and Heat.

Still there are a few cases of the actual transference of Light as a radiant. The new element Radium is declared to transfer to bodies its power of radiation of Light and to emanate substances endowed with its own radio-active capacity.

Becquerel made the discovery that uranium would emit rays spontaneously without previous exposure to the sun. It is itself a kind of sun shining by its own radiation, which does not diminish the luminous substance. It is a new property of Matter, or Matter with its new property, which has been specially called radio-activity. It is said that any substance placed near radium acquires radio-activity for hours and sometimes for days, even after the removal of the radium. This is declared to be the result of the so-called emanation or gas of radium which settles on bodies and then leaves them. The *x* emanation produces helium, which is set down as a new chemical ele-

ment. So it seems that the luminous ray has its field of transference.

II. Light Separated. The ray of Light can be separated in various ways. First it can be suddenly turned from its direction or broken crosswise, refracted, as the books say. Then it can be separated within, decomposed into colors which are in turn variously refracted, producing the spectrum.

It will be noticed that this second stage of Light differs in character from the second stage of Heat. The latter shows its character in expanding the constituent molecules of a body; but Light on the whole turns away from an assault inwardly and reveals its own constitution.

1. *Refracted (broken) Light.* Every person has observed that a stick thrust into clear water seems broken at the line of its entrance. A ray of light, passing out of a rarer into a denser medium or the reverse, undergoes refraction, be it from air to water or from water to air. The molecular medium of solid, liquid, gas, determines the direction of the impinging ray; this finds a new way according to the constitution of the material. The waves of light thus reveal the nature of the medium, which can determine it in various manners.

(*a*) Diffraction is seen when the light ray, after passing through a narrow aperture, branches out at every point of the line. Light thus separates within itself at every point and radiates in every

direction. It not only propagates itself in straight lines, but starts anew lines of propagation. Light shows this inner self-separation, it cannot stay with itself but must thus ray out and manifest itself.

Diffraction has been specially studied by physicists since it shows the phenomenon of interference of Light in which Young and Fresnel saw the first necessity of the undulatory theory.

(*b*) Many refractions can be made to take place through variously shaped media. These are usually of glass and are called lenses, of which a number of kinds appear in the books. They diverge and converge Light, making its rays draw lines which form geometric figures, and show its mathematical properties. One lens refracts many rays to a common point called the focus, while another lens can decentralize Light. A great variety of optical instruments have as their principle the lens; the eye itself is such an instrument. The light ray is thus caught and controlled. Its function is some sort of manifestation, it is to reveal what is hidden in the dark. It has become a pliable instrument, though it be but an etheric wave which radiates itself radiating.

(*c*) A ray of Light can be refracted and then restored to its original direction. When it is passed obliquely between two parallel planes, it deviates according to the medium, but assumes its first direction when it returns to its first medium.

If we look through a glass this phenomenon takes place: a given line of Light through air to the glass, then a deflected line through the second medium, finally a restored line when the air is again entered.

2. *Prismatic Colors.* The separation of a light-ray takes place lengthwise as well as crosswise; or as is said usually, it is decomposed into colors. The prism is used for this purpose, hence they are called prismatic colors. This was the famous experiment of Newton dividing the so-called white ray into seven colors of different degrees of refraction. Thus it was shown that the light of the sun which seems so simple is really a compound.

(*a*) We find, then, that the ray of ordinary or of white light is decomposable, whatever be the degree of its intensity. It grows less in proportion to the square of the distance from its source; still it can always be separated within or decomposed. After reflection or refraction it is still a compound borne by the Ether. Thus the Radiant radiating itself as radiating is internally divisible, it is made up of elements. Light manifesting its opposite as body manifests itself as luminous; but now this luminosity is made to show its inner character by the separative action of a prism. Are the other Radiants thus decomposable? At any rate Light has a chemical suggestion in it, a kind of laboratory which analyzes.

(*b*) The next fact is that each of the seven

prismatic colors is indecomposable, each is an elemental product, comparable from this point of view to the ultimate element of chemistry. If one of the colors be isolated and passed a second time through the prism it is not decomposed, though it is still deflected, coming out a single ray of the same color. The light from luminous bodies is seldom simple, but a compound. Now comes the fact that different bodies give rays of light differently compounded, and hence they can be identified by their spectrum as far as Light reaches. Thus the new chemistry of spectrum analysis rises.

(*c*) The recomposition of Light is effected by uniting its original elements. This, too, was the work of Newton. All bodies have their relations with Light, decomposing it and recomposing it. A green tree is not green but has the power of decomposing Light and reflecting green, or reflecting yellow and blue, which compose green—the other elemental rays being absorbed. Thus Nature separates Light with great diversity. Each body with its separative character shows the same by way it separates and chooses color. Thus something characteristic of the body is seemingly uttered by color.

3. *Light Separated as a Whole.* We have seen Light separated crosswise (refraction) then we have seen it separated lengthwise (the prismatic spectrum); now we are to regard it as a totality separated from two sets of etheric undulations,

one less in number and one greater, or one below and one above. In this way there recurs to the mind the conception of the one common Radiant before any differentiation into the three, or of the one universal Ray of the Diacosmos which itself separates into several vast bundles of Rays, such as Heat, Light, Electricity, and possibly more. Such an universal Ray has likewise its spectrum (often called its scale or key-board), which may be deemed the universal spectrum, quite overarching the whole Diacosmos.

(*a*) The total solar Ray, therefore, shows itself a very composite thing, composite not only quantitatively but qualitatively. It is to be conceived as a bundle not merely of luminous homogeneous elements, but also of non-luminous heterogeneous elements. As a whole the solar ray falls upon a body, not only heating it but working upon it chemically and also electrically. The light thrown upon a photographic plate will change its chemical character; a ray of light will explode chlorine gas, which seems to have the power of decomposing the total solar ray and selecting the chemical element.

(*b*) The inner qualitative separability of the solar Ray is, therefore, manifested—manifested doubly. It has a chemical reaction as well as heating power, along with its luminosity. It also possesses the power of transforming itself into color by what seems hardly more than a mechan-

ical separation. We have to distinguish between the simple light-ray with its special properties, for instance reflection and refraction, and the total solar ray which along with mere light has a thermal, a chemical, and doubtless an electrical ingredient.

Here another problem rises. The velocities of the thermal, luminous and chemical undulations are very different, and are set down as successive in the spectrum or scale of the Radiants. Still they seem to coexist and to act synchronously in spite of their very diverse wave-lengths, which apparently have also a kind of unity in the one solar ray.

(*c*) The chief modern act in the separation of Light is what is known as spectrum analysis. The Light passed through the prism, as it comes from different luminous bodies, is found to have different spectra, so that the spectrum becomes a test of the chemical composition of such a body. So we have learnt what is burning in the most distant stars. The spectrum is found not to be continuous in light or color, but to be crossed by a great number of dark lines more or less narrow. The English physicists cannot get over the fact that the great Newton totally failed to notice these lines. Some observers (for instance Wollaston, in 1802), remarked them in a passing way; but it was left to a German optician of Munich, Fraunhofer, to study and describe them in detail.

These dark limits are chiefly the defining principle of the spectrum; they in the main tell the substance which is sending out the light. So the spectrum through the Fraunhofer lines specializes itself indefinitely. Light, being bounded within itself by its opposite, darkness, gets to have a kind of articulation (like speech) or a chain of vocables which is telling us much in these days from the most distant spheres.

III. Light Generated. In one sense it is easy enough to see Light generated; it can be waked up by striking a friction match. But Light in such a contrivance is only stored; what made it originally? It had to evolve in the total movement of Nature of which it is a given stage; ultimately it has a psychical character which must be expressed in psychical terms, if it be correlated with the universe. Yet Light has also its phenomenal side which must be described, tested and measured. In this last case it has a number of sources of which a brief note may be taken.

1. *Primal Sources.* These are essentially cosmical; indeed there is required the physical All to produce one of its parts or stages. The Earth shares directly in the universal illumination which the total Cosmos produces through its own process in order to come to a manifestation of itself. The world is not only seen, but in a sense sees itself, through Light. We have to think that the firmament beheld itself long before the existence of any

eye, which it probably helped to evolve. The *Earth* is supposed to have within its rind a good deal of this original Light, which bursts out in the volcano. The *Sun* is still a source of elemental Light whose primordial form can probably be seen in the self-luminous nebula carrying us back to the *Cosmosphere* with which Earth, Sun and Stars took start in their evolution. Light reveals and in a way associates the separated physical universe, showing it in its separation yet conjoining its parts in a common medium.

2. *Secondary Sources.* These are the ordinary modes of producing Light on our earth, more or less transient, in contrast to the relatively constant sources of the preceding cosmical illumination. Similar to the case of Heat, Light can be produced *mechanically* by friction, also *physically* through electricity, and *chemically* by combustion. The variety of these sources of Light is very great and need not be here detailed. Phosphorescence is applied to bodies which become capable of emitting light with little or no heat or combustion. The phosphorescent object is endowed with a self-luminous power from manifold sources which are discussed specially by Le Bon in his "Evolution of Forces"

3. *Light Measured.* That Light moves at a measurable speed—so many miles (196,000) in so much time (one second)—has been already mentioned. This measurement of Light was the start-

ing-point for finding the velocity of other Radiants, all of which have the same speed per second through the Ether. But this identity of rate contains a great diversity of undulatory forms; Red has 34,000 waves to the inch, Violet at the other end of the visible spectrum has quite double as many. The corresponding numbers of waves for producing the sensation of these two extreme colors are set down as 400 millions millions per second for Red. and 800 millions millions per second for Violet. It should be stated that these measurements vary somewhat in different authors; the foregoing figures are Lord Kelvin's. The visible spectrum is but a small part of the total spectrum of all the Radiants; above and below are found what are called invisible rays of Light.

We have now reached Electricity which is the third Radiant of the present stage of the Diacosmos.

III. Electricity.

This word we intend to use in its wide sense embracing Magnetism, Electricity proper (frictional), and Voltaic Electricity (chemical). In fact these three divisions form the basic process of the entire subject and are ultimately to be seen together in their unity. Yet each of them has its own process which is to be looked at by itself. First, however, we may well try to grasp the electrical idea in its entirety.

The first picture displayed in the books under tnis head is that of the loadstone attracting iron filings. This is indeed a very suggestive phenomenon, and can be regarded as the prelude of the whole sphere, forecasting what is to come. There is the new center different from the earth's center and attracting by its own power particles of matter in opposition to gravitation. That at least hints its diacosmical character. Then there are the lines of filings which seem to radiate in all directions, like rays of light from a luminous body. Here we behold the Radiant not only manifesting itself but actually taking-on a material form and shooting-out iron sunbeams. But this is not all. When the particles are free to arrange themselves according to their inner bent, we behold them forming curves from one end of the magnet to the other; they make circles of themselves, which strive to return into one another, and produce a series of concentric rounds about the magnet. Finally the power of radiation gradully diminishes till it quite ceases, forming a magnetic field with its bounds. In all this there is a surprising similarity to Light which now seems to incorporate itself, each magnet showing itself a little sun with lessening radiance from the center.

Many years ago Faraday observed what he called lines of force which circled about a magnet from its center outwards. This magnetic phe-

nomenon is indeed pivotal and differs from the luminous appearance which has just preceded. There is still radiation but the lines of energy strive to bend around into curves whose ends come together. That is, the Radiant is now self-returning and seeks to make a circuit of itself. Such is, indeed, the pervasive characteristic not only of Magnetism proper, but of the whole sphere of Electricity. The radiant Diacosmos has become cyclical.

The Diacosmos is in general that department of Nature to which Electricity belongs as different from and indeed opposite to the movement of the Cosmos. Electricity runs counter to gravitation and radiates in various ways; so we must again see it as a Radiant pulsing its vibrations in an Ether. It is moreover the third stage of the second or radiating Diacosmos, its two antecedents being Heat and Light, with which it forms a process, verily the total process of the Radiants. Heat we have seen to be an immediate forthright radiation of a form of Motion, which takes the molecules of the material body along with it, thus expanding it and often breaking it to pieces. Electricity will, we may say, return to Heat and generate the same with an enormous energy, which will liquify and even gasify the most refractory substances. At the same time Electricity will be a marvelous generator of Light, presenting the world with a new illumination. Electric Heat

and Electric Light are getting to be among the most important of these kind of Radiants, with an outlook of the vastest magnitude. Light, however, radiates itself, like Heat, outward and onward without return to its origin, unless through the All. But the salient fact about Electricity is that it has the inherent tendency to turn around into itself; if it separates from itself and rays forth (thus being a Radiant) it also wheels back or strives to do so, finding whence it came. Hence we see the basic characteristic of Electricity to be the circuit.

The fact of the circuit, then, is what permeates and unifies all the diversified phenomena of Electricity. This is also what makes it emphatically the third in the order of the three Radiants, which order, though it shows the process of this whole diacosmical sphere (the second) is too often disregarded in the books on Physics. Electricity is, therefore, the self-returning Radiant as distinctive, not merely the self-radiating (like Heat), not merely the self-radiating and self-manifesting (like Light); it is both of these indeed, but likewise itself, being cyclical in its radiation. The arc-light illuminating your room is an electric circuit giving off both Light and Heat.

Thus Electricity thus performs a double round: it has its own special circuit, and then it takes up the entire circuit of the three diacosmical Radiants. In fact it seems to go back to the Cos-

mos and to employ the attraction of bodies in a new way, and to combine it with repulsion, thus forming a circuit of attraction and repulsion, as we see in Magnetism. Of course the power of the electric circuit is specially manifested in Voltaic or dynamic Electricity. Here we see also that Electricity is a liberation of energy (like Heat and Light) from its material enthrallment, but moves in its own way back to its origin and thus completes the purely emissive radiation of Heat and Light, which may be even made to appear as parts of its cycle.

Electricity is, accordingly, a form of Motion, a radiant form of it, self-separating yet also self-returning. Motion in its primordial form we have called the Separating and Matter the Separated; the two are opposites, the very dualism of Nature, whose process is to unite them, to mediate their conflicts. In the Cosmos we saw Motion returning into itself in the orbits of the heavenly bodies, which it bore along from the outside as it were in its circuit. Such was the realm of gravitation. But now in the Diacosmos, Motion as electric is separated from dissolving bodies (say zinc and copper with acid) and radiates itself in a circuit; or it vibrates itself through an Ether around into its beginning. Thus Motion as pure and unbodied has revealed itself as cyclical; that is, it does not now carry its bodies along, as we saw it doing in the Systemic Cosmos, when it bore

the Earth around the Sun, for instance. At present Motion as electrical separates from material body, (though the latter is still its source and support) and moves of itself always around into itself, showing doubtless in the smallest magnetic circuit a phase of the original elemental form of itself in its first separation from the All-Self. Thus Electricity we call a form of Motion as well as Heat and Light, with which it is correlated in the one process of the Radiants.

And now must take note of what seems to be an exception in this ordering of the Radiants. Upon their general spectrum (or key-board) Electricity is placed lowest, that is, it has the greatest wave-lengths. Much above it is Heat, and then follows Light (starting with 34,000 waves to the inch). But above the light-ray is placed, not the electric but the actinic or chemical ray. Thus the scale of Radiants seems to be dislocated. Still there are said to be among these short ultra-violet rays some which can be called electric. There is a good deal of doubt about the X-ray, but it appears to belong in the upper spectrum. Even the Hertzian ray, usually set down as very long, is declared by some investigators to have its very short counterparts. Then the actinic ray may well have its electric part, since chemical action produces and is produced by Electricity. Evidently there is much uncertainty hanging over this portion of our subject. We may, however,

consider Electricity to have its special place and manifestation in the total scale of the Radiants, but at the same time to be at work in the background of the whole of it, from top to bottom. We have noticed something of the same sort about Heat; it has its own field, yet is found along with the other Radiants. It would not be surprising if Electricity, though bounded specially against Light and Heat, would turn out the universal Radiant even by actual experiment; in our thought it is so already as the cyclical or self-returning Radiant, completing and embracing all three forms of what we here call the radiant Dia. cosmos. Perchance the electric ray will yet be found to bend around from the last octave to the first of that universal key-board of Heat, Light and Electricity (which the scientists have even pictured), thus making the universal circuit of this entire field. At present, however, we must be satisfied with grasping Electricity as endowed in its own special field fundamentally with the radiant circuit, of which it will show numerous forms.

We have already forecast the general movement of Electricity in its three stages of magnetic, frictional (static), and chemical (Voltaic). Moreover we are to see that these stages are not only divisions of the subject but form a process together which unifies and orders electrical science. The following may be taken as a brief outline of its movement.

1. *Magnetic Electricity*—given by Nature directly in a physical object, and hence immediate; it manifests the electric circuit in the most direct sensuous way.

2. *Frictional Electricity*—excited primarily by an assault upon the molecular structure of the body, or rather of two bodies; it shows two kinds of Electricity and two kinds of circuits; it is the dual stage of Electricity.

3. *Chemical Electricity*—excited by decomposition of the atomic structure of two substances (usually metals) which, however, unite in a new sort of electric circuit, known as Voltaic (or Galvanic); its power is the greater, as its negative might in assailing the atom is the greater; it also returns to the simple magnetic circuit with marvelous results.

These designations spring from the origin of the different stages of Electricity, which can be natural, molecular, or atomic. But they all manifest some form of the electric circuit, which is to be grasped as their common principle. (The word *static* or *Electrostatics*, as applied to frictional Electricity, which does not stand still, is misleading, and hence is to be avoided).

I. Magnetic Electricity. Often called simply Magnetism, which has long been known. The magnet (or loadstone) is a product of Nature herself; the name is said to have come from Magnesia, in Asia Minor. It is an oxide of iron and is

found especially in the iron mines of Sweden and Norway. Thus Magnetism is something primarily given, not produced though producible, as we shall see; it is an immediate native presence in Nature, and is almost wholly confined to one material object, which has been physically endowed with the power of degravitating in a limited way the supposed universal gravitation of the Earth. Up to a recent date Magnetism was treated as something by itself alone, as an isolated phenomenon; but at present it is regarded as a stage of total Electricity.

Magnetism is, therefore, an integrating part of the entire electrical movement as one of the three Radiants. We may deem it an implicit Electricity, the first stage thereof, not yet manifested in light or the electric spark which is so characteristic of frictional Electricity. Still there is the electric circuit, which shows not in itself by becoming luminous, but by its effect seen in external bodies, as in the case of iron filings. The movement of Magnetism may be grasped in the three main forms of the magnetic circuit; first is the simple one, that of radiation; second is the circuit divided into positive and negative poles, or polarized; third is the circuit restored and united—which fact we see in the horse-shoe magnet with its armature.

(The story of Mahomet's steel coffin suspended by loadstone at Mecca, also that of the iron

statue of Queen Arsinoe hanging from the magnetite iron of her temple's roof, are magnetic marvels embodied in legend; the iron steed of Bellerophon galloping through the air while upheld by magnets at Rhodes, was one of the fables celebrating the wonder of Rhodian art),

1. *Circuit Radiated.* It has been remarked that Magnetism does not show itself but has to be shown by something else. The ordinary material (we may repeat) is iron filings brought near the ends of an iron magnet. These arrange themselves in radiant lines about each end as center. Thus a magnetic rod has two centers of radiation, both at the ends, while in the middle there is no attraction. This is called the neutral line. Thus Magnetism divides the one object into two opposites centers, each of which has quite equal power. Here we behold the first appearance of the electric circuit, out of which the other forms may be considered to evolve. Noticeable is the fact of very small particles arranged by magnetic force as if they might suggest the molecules in the same activity.

(*a*) Attraction is thus the primal category of the magnet, as we saw it to be of cosmical Matter. Every body in the physical universe is said to attract every other and to be attracted by it—the doctrine of universal gravitation. But magnetic attraction is strangely confined to one element, namely iron, and this has to be in a certain attractive condition. Thus we behold iron at-

tracting iron and manifesting such attraction decidedly to the senses; we may deem it a kind of concentrated attraction in small objects, which otherwise is dispersed through the entire material world, and is very slight except when manifested in planets, sun and stars. Moreover such attraction spheres itself visibly around a center.

(*b*) This magnetic attraction we are next to see dividing into two centers in the magnetized bar, each end of which radiates the power, and draws the small particles of iron. Thus the bar is decentered by Magnetism, as regards gravity; the center of gravity in the bar is made indifferent to Magnetism just in the magnetized object, and is sundered into two end-centers. Herein we may see the one attraction, primarily cosmical, to be separated into two diacosmical attractions of Magnetism. According to the law of gravitation, the iron bar should draw to its center every little bit of iron, which attraction is infinitely small; but according to the law of Magnetism the particles of iron must fly from the one center in the middle to either center at the end. Moreover two spheres appear, each being manifested visibly in the particles around its center.

(*c*) Accordingly around each of these end-centers are manifested lines of circular motion, or of magnetic force, as the books say. If a thin card be placed upon a magnetic bar, and iron dust fall upon the card through a seive, the particles will

arrange themselves in curves around each of the end-centers. This shows the concentric circuits radiating around each of these end-centers. Moreover these circuits reach out to a circumference in proportion to the power of the magnet and to the distance of one end-center from the other, the two fields curving around into each other. But the main fact is the central radiation and its circular form. This may be deemed the primal electrical circuit manifested; it is indeed magnetic, but Magnetism is the first stage of total Electricity. The circuit, the basic electrical phenomenon, has now appeared. But this visible radiated circuit dualizes itself.

2. *Circuit Divided* (*Polarized*). We have just seen the magnet divided into two magnets, each of which radiates a sphere of concentric lines of force. These two end-magnets were quite equal and alike in power; but now they show themselves opposed to each other, symmetrical counterparts of the magnetic bar. These are called poles, each of which is placed near the end of the magnetic bar. The latter has now three divisions: the positive, neutral, and negative portions. The two poles are true opposites, each is through the other, neither can do without the other. This is strikingly shown by the fact that the positive pole cannot be chopped off from the negative pole and be made to stay with itself alone; the half will still have both poles.

(*a*) We have already considered magnetic attraction which is equal and like as to power in both the end-magnets. At this point, however, enters the fact of polarization, which involves repulsion also; the end magnets are opposite poles of the one magnetic bar. For if a second magnetic bar be brought near the first, the like end-magnets will repel each other, and the different will attract each other. Or, as the law is usually given: poles of the same name repel, and of opposite name attract. It is evident that the two contradictory poles seek to come together and form one process or circuit. In this way the two magnetic bars are united at both ends, and the round is complete. Thus two magnetic bars may be conjoined in two circuits.

(*b*) The Earth is a magnet or rather a kind of magnetic bar with two end-magnets, that is, with two magnetic poles, which are not far from the geographical poles. Consequently all magnets on the earth's surface, if free to move, adjust themselves to the great terrestrial magnet, magnet of magnets for us. Thus we have two kinds of magnets, the universal one (or relatively so) and the many particular ones scattered over the face of the earth, each of which points its one opposite pole to the North-polar magnet, the other Southwards. This fact is utilized in the Mariner's compass. Note that its South pole as opposite points Northward, though usage of speech calls it the North pole of the needle.

There are many interesting facts in connection with the vast terrestrial magnet, which has its own movements. It deflects the needle from due North (inclination); it draws the needle down more and more toward the perpendicular, the farther it is carried Northward (dip); its horizontal force is greatest on the Equator. These are all manifestations of the universal magnet determining the particular magnets over the whole earth—the needle being only the example in its free movement. Gravitation also draws the needle toward the center of the earth, while magnetic attraction furnishes two new centers at the ends of the Earth.

But now comes the curious fact that terrestrial Magnetism is not a totality but is determined from the outside. So it is still in the divisive stage.

(*c*) What are known as magnetic storms are seemingly caused by the Sun, being sent out from its disturbances, which are supposed to produce strong magnetic circuits upon and around the Earth. These often disturb the telegraph for instance. They are connected with the solar spots which seem to be sources of radiated Magnetism that reaches and swathes the Earth. The Sun thus becomes a kind of magnet whose power extends to the planets revolving and wrapping around themselves its currents. The whole planetary system is a Magnet; the Heliosphere was one with its poles. Thence we advance to the Cosmosphere or total physical universe. These sun-spots with their

magnetic effects upon the Earth occur periodically, once in eleven years it is estimated.

So we have perchance all Nature as one great Magnet, divided into lesser magnets, such as sun, planets, as well as our own earth, with its infinity of magnets. For us the sun seems the source of Magnetism, as also of Heat and Light. And yet the sun, too, even in its magnetic power may be able to make the solar system a magnet, and it may have derived its Magnetism originally from the Cosmosphere. This would then be the bearer of the universal magnetic circuit from which all others have been derived.

3. *Circuit Restored.* In the preceding sphere we saw the magnetic circuit divided, with the two poles as centers, each of which was the opposite of the other and had its own sphere of influence. The next step is that these two separated and antagonistic poles must somehow be brought together and conjoined in one circuit, which thus restores both out of their separation, and makes them stages of one movement deeper and stronger than either. The outcome of Magnetism, therefore, will be the circuit united within itself and moving through the magnetic body, its circular activity having become internal from its first external appearance (in the iron filings).

(*a*) First we may consider magnetization. A magnet has the power of imparting its peculiar quality; magnetism can be transferred from one

piece of matter to another. Iron or steel is the chosen bearer of magnetism (with nickel and cobalt), but different specimens of iron and steel show different powers of receiving and retaining the imparted magnetism. The earth will magnetize a rod of wrought iron placed in the magnetic meridian, though such a magnet does not last unless hammered or twisted. The Earth has a tendency to magnetize all iron when in the right position for the current. A knife-blade or needle is magnetized by rubbing it with a magnet. Electric currents are the most powerful means of magnetization.

Indeed Magnetism is a form of magnetic transference from one center through several objects. A pair of shears will pick up a needle and hold it by magnetic attraction; the needle will hold another needle, and that another, and so on, according to the power of the magnet. In this case Magnetism shows itself radiating from a center and holding in a line different objects. The same principle is what radiates the iron filings around the pole of a magnet; each particle becomes a magnet drawing and holding its neighbor. Thus through induction Magnetism shows a unifying power over separated objects, assimilating them and conjoining them in a common character and action.

(*b*) If we cut a magnetic bar into two equal parts, each part becomes a complete magnet with its two poles. If then these parts be still further

divided, each division and sub-division is a magnet. We cannot, therefore, separate one pole from a magnet, making it unipolar; the positive pole cannot exist without the negative, and vice versa. The magnetic body may be divided in the middle just at the neutral line, still the separated pole posits it opposite pole at once. Thus each individual body becomes a magnet, and the separated ends as opposite poles attract each other. In this way Magnetism is connected with cohesion, which when broken through separates, and we may say individuates Matter, each portion of which can become a new body.

Nay if we carry out this principle of division to the final unit, the molecule (or even the atom) we may infer that this too will be a magnet. As all matter, however rigid, is supposed to be discontinuous in its molecular state, we have here the conception of body made up of magnetic molecules, trillions to the cubic inch. The theory of magnetization lies in the order of these minute particles, each of which has its South pole and its North. When the opposite poles of these particles are together they are in equilibrium, and can constitute no magnet; but when like poles are conjoined and are deflected from the opposite ones, there is a common tension of them which is manifested in their Magnetism. This is, then, not a thing, but a force springing from many infinitely small, molecular magnets.

(*c*) This force separated and polarized in the ordinary magnet with its positive and negative poles is made into a circuit when these two poles are brought together by a mediating object. This is best seen in the horse-shoe magnet with its armature. The two opposing poles of a rod are bent around toward each other, then they are connected by a piece of soft iron. The power of the magnetic circuit is indicated by the weight which can be suspended from the armature without breaking its hold.

We now witness the double and hostile polar circuits of Magnetism reconciled in a common circuit, being mediated by a sympathetic metal of the same kind, which takes up into itself and harmonizes them in and through itself. Thus Magnetism has run its course, having passed from its outer, purely natural, visible state to its inner invisible circuit, whose unity is shown in all its power by the way in which it binds to itself its reconciling principle, the armature, which has before it a great destiny. Thus we have unified, and as it were, internalized the first electric circuit, whose outer and separated forms we have already considered. The tension between the two poles of the magnet is overcome by what may be called the diamagnet (armature) whose character is just this mediational act. (The word *diamagnetism* is, however, employed in a different connection). But now we are to behold this one electric current becoming dual in a new phase of electricity.

II. FRICTIONAL ELECTRICITY. As distinct from magnetic or natural (spontaneous) Electricity, this sort is artificial, being produced by friction, percussion, pressure, fracture, and other mechanical means. There is in it a prevailing twofoldness: two substances are required and must be brought into strong opposition by a mutual assault of some sort; two opposite kinds of Electricity are generated, with their two circuits. Electricity is thus dual in its nature compared to Magnetism, which, however, has its two poles in the one substance, each of which remains self-attractive and does not turn self-repellent. The name is taken from an old Greek word *electron*, which in the present case means *amber*; this being rubbed produces a peculiar diacosmical attraction, which is said to have been noticed by ancient Thales, the Milesian philosopher, in the sixth century B. C. The word *electricity* seems to have been first used by William Gilbert of Colchester, England (1540-1603) who also has handed down the needful term *electrics* for electrified bodies, and who clearly expresses the idea of an electrical force (*vis electrica*).

In Electricity, therefore, two substances are made to attack each other's molecular structure by an outside power. Hence Electricity proper must involve a movement and change of the molecules; they make two attacking armies in a fight more or less furious. Such is the strength or intensity of

this molecular motion that it draws light indifferent bodies into its whirl, till they in turn become charged with combat and fly off in opposition. That is, Electricity must dualize itself, else it would be simple Magnetism, which holds the attracted body as its own. The magnet is one, but two are the electrics. If the one magnet is made two by division, there are simply two like magnets; if the two electrics are made one (by attraction), this one electric repels itself and persists in being two. Such is the basic phenomenon of the second stage of Electricity: the electric both holds and repels its own, itself; thus it reveals its own inner self-opposition as character. Inherently dual we have to regard it; dialectical we may deem it, manifesting to vision that dialectic of Nature, which has been so often noted already. Still these two sides form circuits, each in itself and then with each other. Also the dielectric will appear in a certain parallelism with diamagnet.

1. *Radiation.* This twofold Electricity is a Radiant, but its radiation is not only from two centers but is of two opposite kinds. In Magnetism there was radiation from the two polar centers, but of the same unrepellent sort from the same object; but now the radiation is of two different sorts from the two different objects. Two circuits of opposite natures constitute the electrical interplay, which circuits, however, are at last to be united.

(*a*) The primal fact then of dual Electricity is

its separation into two sorts which are in two distinct bodies. This is done chiefly by friction, which assails the cohesion of the two bodies; each is made the means of destroying the molecular structure of the other on the surface by the application of external force. When a glass rod is rubbed by a piece of flannel, each part will draw to itself light bits of silk, wool, gold-leaf, etc., which after a brief contact are repelled. These rubbed substances also become luminous in the dark and give forth sparks of light. Here at the start is manifested a round of attraction and repulsion—a double radiation of force. Moreover the terrestrial attraction of the object is overcome by this new power of a piece of Matter; cosmical gravitation is for a time counteracted by this diacosmical energy.

(*b*) So we behold electrical attraction and repulsion, in which an object is drawn from and drawn back to its line of gravity. Next we are to see that this attraction and repulsion is doubled; the object rubbed and the object rubbing have both this power. Thus the first twofoldness is again made twofold. Here rises the conception of two electricities, opposite yet each determined through the other—positive and negative as they are called; each has its own round of attraction and repulsion; the law is, likes repel each other while unlikes attract each other. Two sets of attraction and repulsion we observe, opposite yet

with a similar round of the electric current. The disturbance of corporeal cohesion through friction has generated within a limited sphere a force greater than the earth's attraction.

(*c*) The lines of electric force are conceived by Faraday to run from positively charged bodies to negatively charged ones in an electric field where they exist. There is a radiation outwards from a positive center to its opposite, whereby the two electricities are interconnected and form a circuit. In such a field too there is what is called an electric potential which has been compared with the temperature around a heated body. The law runs: between two electrified bodies attraction or repulsion is universely proportional to the square of their distances. Double the distance, one-fourth the power. This goes back to the law of gravitation, which is for the time supplanted by electrical attraction or repulsion. Electricity causes the little body within its field of power to take the place of the earth and to attract (or to repel) another body (not too heavy) according to the law of gravitation. The cohesion of the molecules is disturbed by the friction and asserts itself by strong reaction toward unity (which is assailed), drawing into its movement small light bodies not far off. Finally, however, the Electricity spends itself and equilibrium with the earth is restored.

This fact comes out: electrical attraction and re pulsion pre-suppose terrestrial attraction as some-

thing to be overcome and supplanted. The suspended pith-ball which is drawn to an excited glass rod is carried out of its line of gravity with the earth's center toward a new center. This is the diacosmical action of Electricity. The pith-ball or electrifiable body gravitates towards the electric, as it before gravitated earthward. Cosmical gravitation becomes a diacosmical gravitation in Electricity; so we have seen it also in Magnetism.

2. *Electricity in Dual Circuit.* The twofoldness of Electricity has been set forth, its tendency to divide into two opposite forces, both of which must be deemed Radiants against each other. Sometimes this has been called a decomposition of one original compound force into two elemental forces, as Light was decomposed. Magnetism was polarized into two end-magnets, whose law was like repels like and attracts unlike. This law holds of like electrics, as well as of like magnets. But the magnet does not impart its own self and then repel the iron filings which stick fast and become holders or conveyers of Magnetism. The electric, however, attracts its other, then imparts itself to the same, and finally repels it as like. This repulsion shows the movement from Magnetism to Electricity: the magnet imparts itself but the electric both imparts itself and repels itself as like. This is the point at which we witness the oneness of Magnetism passing into the doubleness

of Electricity. Also the materials change; if the magnetic object be chiefly one (iron), electrics are many and of opposite kinds, as glass and gutta percha. Iron falls away and the metals, being conductors; iron the magnetic substance, is not the electrical.

Still Electricity has the power of imparting itself as dual, as attracting and repelling (positive and negative). Moreover it becomes double-circuited, starting from either side and going either way in its round. So we have the process in this stage: conduction (likeness), induction (difference), unification of opposites in the circuit, yea double unification.

(*a*) The dualism of Electricity primarily divides matter into electrical conductors and non-conductors, which form the present division of substances as regards their conveyance of electricity. Only the rubbed side of a glass rod is electrified, the other side not; hence it is strongly non-conductive. On the other hand metals at once conduct the Electricity throughout their substance. Silver is said to be the best conductor, gutta percha the best non-conductor; between these extremes is a great diversity of conductive power in things. The best manifesters of Electricity are, therefore, the non-conductors, and they have it only in the rubbed surface; the unreached molecules remain at rest

But the non-conductors are still further divided

into two classes—negative and positive electrics. The same substance can be both, excepting possibly the extremes which are usually set down as catskin and gutta-percha.

(*b*) A deeper phase of this self-divisive Electricity is electrical induction, which occurs when a charged conductor is placed near an uncharged body—separated from it but in its electrical field. The result is Electricity is induced of the opposite kind, and if the uncharged body be a metal bar, each end will also have its charge. Thus the bar resembles a magnet, having its two opposite poles of induced Electricity. Induction is not stopped by any intervening medium, though this be a non-conductor, such as glass, if the object be in the electrical field. Thus Electricity is imparted both by conduction and induction; still in the former case the imparting body loses a portion of its electricity but not in the latter case. It imparts its own kind of electricity by conduction, the opposite kind by induction, which fact separates the electrical force again into two phases.

(*c*) From the induced separation into opposite electrics there results the recombination which makes the circuit. The attraction and repulsion of the pith-ball came from induction. The decomposition into the positive and negative electricity is followed by this recomposition, which can be made a continuous round by conduction starting with the one or the other.

Thus we have to conceive of two circuits according to the dual character of Electricity; which, as the character given, is what will be imparted. Two decompositions of electricity and two recompositions, not, however, back into the original single Radiant, but into two circuits, which also go in opposite directions. Both these circuits can be shown in the Leyden jar, which has the two opposite electrics with their dielectric (the glass sides of the jar). This dielectric, however, does not mediate (like the diamagnet) but separates and can be broken by the tension of the two electrical foes.

3. *Electricity Generated.* We have seen electricity imparted in various ways, but how did it start or first come into activity? In the opening section we took for granted its origin from friction, or from the primal disturbance of molecules on the surface of certain bodies—non-conductors.

And this is to be noted; Electricity is superficial, it does not go deeper than the skin of bodies when it manifests itself. But in conductors it is distributed through the whole body and conveyed away in a kind of stream, unless insulated and thus stopped. All electricity may be deemed frictional in origin, not only by direct contact but also by impact of electric force borne through space (or the air) to a body in its field.

Thus the finite world of individual bodies rubbing and rasping against one another becomes one vast

mass of electrics and electrifiers, producing an infinite number of electrical circuits. Mechanical impact in the Cosmos generates the Electricity of the Diacosmos, and the force of gravitation is turned from the earth and given its own special centers large and little. So this present diacosmical Radiant fills our world and perchance the universe with electric whirls, which spring from impinging or colliding matter. Every individual substance has a kind of soul of its own, which is roused by another substance assailing it; so they stand in antagonism, but therein are alike and hence can be made to come together.

(*a*) Friction brings forth different electricities (positive and negative) in the substance by the use of a different rubber. For instance glass is negatively electrified by rubbing it with flannel, and positively electrified by rubbing it with silk. Per contra, through the double friction flannel becomes positive and silk negative. In like manner resin stroked with india-rubber is negative while the india-rubber is positive; but if the resin be rubbed with sulphur, it becomes positive and the sulphur negative, which however can be turned positive by gutta-percha. Thus all substances can be made into a line of electrics, both positive and negative according to the rubber. All substances can be arranged into a line of electrifiers by friction, exciting both positive and negative electricity according to the substance. Each is an electrifier and an electrified, and each

is an electrifier doubly (positive and negative) and each is electrified doubly. Thus Electricity dualizes, yea doubly dualizes our particularized Cosmos.

(*b*) Along with the electric Radiant is usually evolved the two other Radiants: Heat and Light. Friction will likewise generate both. Heat is generated by rubbing the metals, but the Electricity is mostly conveyed away. Light appears when the circuit is broken and a non-conductor inserted, like air, through which the spark leaps luminously to complete the circuit. On a larger scale Nature shows electricity at work during a thunder storm with its flashes of lightning, evidently between two huge electrics of opposite kinds. In the Aurora Borealis, though the phenomenon belongs to both poles, the earth has become a huge electric, probably through friction of the air and tides and currents and solar influence and its own rotary motion. As there was a terrestrial magnet, so too a terrestrial electric is generated by friction and is made luminous by some unusual obstruction. The sun, too, is an electric, and so was doubtless the original Heliosphere.

Heat, Light and Electricity, the three Radiants of the radiant Diacosmos are all separately generated in the electric circuit and appear in their own form and character. Yet they show themselves also as parts and stages of one process; they make up the cycle of diacosmical radiation which is thus actually manifested—not an hypothesis, not a thought merely, but a phenomenal presentation.

This process is what lay originally and implicitly in the diacosmical separation and reaction from gravitation. Motion as radiation from a center has vibrated through the Ether in Heat (expansive), in Light (manifesting, and self-manifested), and in Electricity (the self-returning undulation).

It may be added that Heat also generates Electricity with its circuit—to which phenomenon we may next pay a little attention. Such a circuit is usually called the thermo-electric.

(*c*) To make the circuit appear let two metals be taken, bent and brought together at their ends; if one of these ends is heated when the object is placed in the magnetic meridian, an electric circuit is developed which can be shown by a needle balanced on a pivot. This, the discovery of Professor Seebeck of Berlin in 1821, and is the basic phenomenon of the thermo-electric circuit or of the electric circuit generated by Heat. Thus the first Radiant (Heat) is made to produce the third, or the third is brought to embrace the first in its process.

It is evident that when the metal is heated, its electrical character is changed.

Also different metals are differently affected in their electrical condition by the same degree of Heat. These thermo-electric metals are also paired off in counterparts, like zinc and copper in the Voltaic cup. Bismuth and selenium produce the strongest thermo-electric current; but for economy antimony is most used. Every metal, however, has

its thermo-electric potential and can become a positive or a negative pole of a circuit if connected with another metal and heated a little. Evidently such circuits are everywhere arising on the surface of the earth in the sun's rays, though they are in general very slight.

The power of the thermo-electric circuit is increased by the thermo-electric battery, or the so-called thermopile built after the fashion of the Voltaic pile out of the preceding thermo-electric couples. This pile is named after Nobili, the inventor, but has never been much employed in the arts. The electromotive force of this circuit is low compared to a Voltaic one; it is chiefly used in determining the temperature of things difficult of access, as objects in a furnace. Melloni employed it in his experiments on radiant Heat already mentioned.

Probably the most important use to which the thermo-electric circuit has ever been put, was to ascertain Ohm's law of the strength of the electromotive circuit, which is directly proportional to the electro-motive force, and inversely proportional to the resistance. In this connection it should be noted that the earth is a great thermo-electric battery, being diversely heated and cooled every twenty-four hours. The sun is always warming up one half more than the other—which is the condition of a thermo-electric current embracing the globe. Then we have to conceive the vast number of smaller circuits netting its surface everywhere.

But far more powerful and important than the thermo-electric circuit is the chemico-electric circuit which comes next in order. Electricity generated from the attack on the molecules by mere Heat is weak in comparison to the electrical power generated by a dissolution of the atoms through Chemism. The separative might of inner atomic disintegration must be deeper, subtler and more intense than the outer assault upon the molecular structure, which is indeed constituted of atoms. To this fact we must now pay a little attention.

III. CHEMICAL ELECTRICITY (VOLTAIC).—Here we behold, first of all, the pivotal electric phenomenon embodied in three substances, the two metals and an acid, whose interaction forms the new electric process or circuit. Electricity, as frictional, had its two substances in opposite activity; Electricity, as magnetic, had practically its one active substance. Thus we grasp the three stages of Electricity as manifested in body: the simple unity, the separation, and the restored unity through the three-in-one circuit. Moreover, the circuit now gets to be the current, one within as well as one without; also it is atomic (chemical) in origin rather than molecular (mechanical).

So we see that the circuit is now explicit; the dominating principle of the stages more or less implicit in magnetism and dualized in Electricity proper, has become real. Hence the circuit is now said to be continuous and not broken into separate

discharges, which make a sudden circuit and then stop, as indicated in successive claps of thunder, or in the sparks of an electrical machine.

Light bodies are no longer specially attracted; not so much a radiation of power from a center do we behold, but rather in a rounding line. The magnetic needle is readily deflected by the circuit, but not by the separate flash. We pass from an electric circuit, intermittent, ever breaking within and dropping back into its electrics, to a circuit broken only from the outside. For this reason the word current is often used in the present part of electricity, as if it were a fluid, and not a radiant. A spark is a characteristic of an electrical machine hardly of the Voltaic battery.

Moreover the transmission of power now becomes possible through the permanent circuit. The intermittent nature of dual or frictional Electricity (even if this might be largely overcome) precludes the application of it as an extensive motor agency. But the present kind of electricity can send power to greater distances than any other force, being conducted by a simple wire, for example in the telegraph.

The round electricity of the current is thus the overcoming of the frictional, separative Electricity, though here too the circuit must be able to be broken, but it is not to break itself.

Metals as conductors now play the leading part, while non-conductors, chiefly non-metallic (animal,

vegetable and mineral) drew the attention in the previous stage. Moreover two metals are usually taken as opposites or counterparts; zinc and copper for instance, are the two mutually counteractive metals in the ordinary Voltaic cell for producing the circuit. Frictional Electricity was confined to the surface rubbed, but Voltaic electricity evidently reaches throughout the atomic structure of the metal as a good conductor. So, metallic conductivity, which would thwart frictional Electricity is now seized upon and employed, instead of the previous non-conductivity. But it is through this metallic conductivity that the electric circuit completes itself, attains the end, we may say, for which it has been struggling. through Magnetism and dual Electricity, both of which have circuits, but incomplete, partial, discontinuous.

We shall also find that this third or Voltaic Electricity, connects with itself in various ways, and produces most of the modern marvels of Electricity. Employing some form of the magnet, its power is drawn off for many purposes. The continuous circuit with steady energy is tapped in its circular movement, and that energy is directed into multitudinous channels. Not only electrical but all radiant motion has become in Voltaism an everflowing, self-returning, hidden whirl of pure energy resembling the primal movement of the Cosmos, in whose elemental revolution it may be supposed to participate. The Voltaic current is a kind of spi-

got or spile inserted in the original reservoir of universal Motion of which it draws off brief cycles for human use.

This third stage of Electricity we may divide, according to its fundamental principle into the three sorts of electric currents: the chemical, the induced or duplicated, the magnetic. Here again we observe the inner universal process at work which organizes not only this electric current but all nature in all its divisions.

1. *The Chemico-electric current.* A pair of frog's legs, prepared for Galvani's dinner by his wife, as as the story goes, was suspended on a copper hook to an iron railing. Whenever one of the frog's legs touched the iron, a violent spasm took place which attracted the attention of Galvani, who, as professor of anatomy at Bologna, held that the source of the phenomenon lay in the muscles of the animal which contained what he called the vital fluid. This view was contested by Alessandro Volta, professor of physics at Pavia, who, true to his vocation, contended that the chief cause of the phenomenon lay in the metals. A controversy arose which led Volta to construct the first battery (called wrongly Galvanic often) and to give a fair explanation as far as it went, of the extraordinary phenomenon.

(*a*) When Volta soldered together a plate of copper and a plate of zinc, he easily found, by simply using his moistened finger, an electric current. This did not come directly from friction, and

yet Electricity was disengaged. Volta's epoch-making theorem was that when two heterogeneous substances are placed in contact, one of them is positively and the other negatively electrified. In this lurks the idea of the two metals as counterparts in producing one circuit. Volta proceeded to multiply his electric couples till he made what is known today as the Voltaic pile. Between each metallic pair he placed a piece of cloth moistened with acidulated water. Here the acid enters and with it the idea of chemical action, which has the power of disengaging the electricity from the metals. The latter have been arranged from this point of view into two classes, electro-positive and electro-negative. Zinc and platinum (or possibly the non-metallic substance graphite) stand as extreme counterparts, that is, as the most electro-positive and the most electro-negative substances. Between these is a list of other metals graded by their electro-motive power; each of the latter might of course be one sort or the other according to its mate. So we have the kingdom of metals revealing their new electric character through the Voltaic pile.

(*b*) The Voltaic circuit has the power of decomposing chemical compounds into their elements. This is the so-called electrolysis, and the substance so decomposed is an electrolyte in Faraday's nomenclature. The products of such decomposition he named ions which are two—anion liberated at the positive electrode (anode), and kation, liberated at the negative electrode (kathode).

Through the Voltaic battery Sir Humphrey Davy decomposed potash and soda obtaining the previously unknown metals potassium and sodium. This was the first great act of electrolysis, which has had many successors. Water, however, had been decomposed by the battery before this (in 1800).

(*c*) So we have before ourselves the general fact of the Voltaic battery with its harnessed power of untold possibilities. The chemico-electric round is now completed, with its energy ready to be tapped for all dynamic purposes. The chemical disintegration of the metals (the zinc especially is dissolved) has let loose all the force of cohesion which originally held their atoms together, and this force has been gathered and consolidated into a self-returning stream of pure motion, which can be drawn off by a tail-race (as it were) to any mill-wheel. But next we are to see this current dividing itself in a peculiar way.

2. *Induced electric current.* Induced Electricity as frictional has already been noticed. But now we are to consider the continuous circuit as induced. This department of electrical science was especially cultivated by Michael Faraday, who elaborated and categorized its leading phenomena. It is the divisive stage of the electric current, indeed it is self-divisive, with a tendency to separate within itself. One Voltaic current will produce its opposite in a different wire of the same field; then the

current in the same wire separates into two opposite streams. Yea we find two currents attracting and repelling each other.

(*a*) The first form in which the present sort of induction appears is that of two metallic conductors, one of which, being in the magnetic field of the other and charged from a battery, will produce a circuit in the other by induction. Two coils of wire of different kinds or sizes, insulated by a coat of silk thread, but close to each other on the same bobbin will show two opposite electric circuits by the galvanometer when one of them is electrified. Circuit accordingly calls forth circuit but of the reverse kind, as its counterpart, in accord with the oft-remarked dual nature of Electricity. One half, though a circuit, seems unable to exist without the other half.

(*b*) Now comes the curious fact that a circuit divides within itself by induction, and we have the phenomenon known as self-induction. The coil of wire on a bobbin is able to induce in its adjacent coil a new circuit alongside of and in opposition to the regular circuit. This was observed by Faraday and he called it the extra current. Such at least is the explanation given of the peculiar effects in a certain class of electric experiments. Thus instead of two opposite induced circuits we behold the same circuit in two opposite induced streams or currents, as if two rivers might run along side of each other in opposite direction through the same bed.

(*c*) Not only the electric circuit induces itself, but also magnetism can induce it. If a magnet is inserted in a coil of wire, the galvanometer indicates the presence of an electric circuit, but if the magnet be removed for a short time and then re-inserted in the coil, another circuit but the reverse of the former is induced. This change springs from the principle that like repels like but attracts the unlike. The earth is a magnet as already noted; hence it can by itself develop the electric circuit. Faraday showed that by turning a flat coil of wire in a vertical plane, when this plane lay east and west, the current appeared; when turned north and south, there was the opposite current. No magnet was present but the earth.

3. *The magneto-electric current.* The notable fact here is that Voltaism (as we may call this third stage of the total sweep of electricity) returns to the first stage, Magnetism, whose final product we saw to be the magnetic circuit. This was realized in the horse-shoe magnet with its connecting armature. The electro-magnet it is now called, by means of which the original magnetic circuit is seized and employed as a constituent of a larger and mightier circuit, being made, unmade, and remade in a new cycle of electric energy. So we may behold, in this magneto-electric round, a returning circuit from Voltaism to Magnetism, physical, indeed, yet also with its psychical meaning.

(*a*) Already it has been noted that Magnetism

can evoke an electric current by induction. On the other hand an electric current can produce Magnetism. Oersted's discovery was an important landmark in this field: it was, that electric currents tend to set the magnetic needle at right angles to their own direction. The next great step was the electro-magnet, or the magnet produced or induced by a Voltaic circuit, which can be successively broken and closed. This is the central principle of the Morse telegraph. The electro-magnet also plays a leading part in the so-called dynamos, which, however, may be driven by steam or water, as well as by the battery.

(*b*) So we behold the completed current of the Voltaic battery working through chemical action, upon the metals. Evidently, chemical decomposition is the source of the electrolytic circuit which has such a furious energy in decomposing chemical compounds into their elements. With this work of the chemico-electric current we begin to approach chemistry proper, which chiefly deals with the original, irreducible elements of the physical universe. The separative character of Electricity, with its final circuit, has reached its outcome in the ultimate separation of material objects, and the radiant Diacosmos, with its circular Radiant, has become the divider of composite things and has led the way into a new science. Also the three Radiants—Heat, Light, and Electricity—have run their course and completed their process. Their common dia-

cosmical character has been to defy gravitation through radiation. But this opposition is now radiated into all bodies, whose molecular cohesion is not merely assailed by Heat, but whose ultimate or atomic constituents are torn asunder in the separation.

(*c*) The various forms of measuring electric energy have been named after distinguished electricians; for instance, the ohm and coulomb, the ampere and the volt. But this branch of the present subject need not be here unfolded, though of great importance in practical Electricity.

Here we are brought to the end of Electricity, having completed what may be called its scientific round of three stages—magnetic, frictional and chemical. In them we have watched the evolution of the electric circuit from its first immediate manifestation to its last explicit form. Moreover with this conclusion we also wind up the process of the three Radiants—Heat, Light, Electricity—which constitute the second part of the total Diacosmos. In these Radiants we behold the common radio-active principle manifested in their different phases. The last appearance in this sphere has been the chemico-electric circuit, which, though the product of chemical dissolution, produces in turn chemical dissolution. Two metallic counterparts (say zinc and copper), being decomposed specially produce a circuit which has the general power of decomposition. The particular dissolution of two

substances becomes through the electric circuit the universal dissolution of all substances. Such a universal separation of Matter into its components, elements, atoms, has brought us into a new stage —the third—of the Diacosmos to which we come next.

CHAPTER THIRD.

THE CHEMICAL DIACOSMOS.

The first chemical fact is the separation of the physical universe into its material elements. These are now set down at about eighty, though this number in different books is somewhat fluctuating. Already we have noted the vast separation of Matter in the Particularized Cosmos; the world of things there appears in its various mechanical manifestations. But now this world of things whose number a scientist has dared hint as 250,000, is to be resolved into its chemical constituents, the so-called elements, which have hitherto been deemed the ultimates of Matter and irreducible, though this transmitted tenet of Chemism has been recently assailed, if not in some respects undermined. Still, the primary chemical idea is that of reducing the whole material universe into its eighty irreducible elements.

Here, then, we have to note the diacosmical character of Chemism. It is inherently divisive, separating the already externally separated Cosmos into its final constituents. Still further, chemical action assails the cohesion of bodies which we have already observed to be cosmical. Then Chemism, with its disintegration, does not primarily obey the law of gravitation, but rather counteracts the same.

We shall indeed see chemical attraction, affinity, re-composition after decomposition ; still such a synthesis is only a part or phase of the total diacosmical sweep of Chemism.

At this place we may observe that the chemical act goes back to the solid, liquid, and gas, which belong to the starting-point of the Diacosmos, and seek to separate them into the elements, if they be not already elemental (for some substances in the form of solids, liquids and gases, at ordinary temperatures, are chemical elements). These material objects, as immediately given, are seized upon, torn to pieces, and then re-formed, perchance, into new solids, liquids, and gases, in the chemical cycle. This process is continually going on in Nature, but the main fact for us now is that man takes it and employs it for his purpose, yea, organizes its varied phases into a science, one of the sciences of Nature, known as Chemistry. (The word is derived from the medieval *alchymistry*, or *alchemy*, whose root, *chem*, has been traced back to Greek, or more remotely, to Egyptian, as its source. E. von Meyer, in his *History of Chemistry*, affirms strongly the original right of Egypt to the thing and the name.)

Chemistry is, accordingly, the physical science which has, as its first (but not its only) task to find the primary original units of which all material existence is composed. This is what our science decomposes into its indecomposable individuals,

each of which is itself and none other; each element is simple, irreducible, asserting its individuality as final against all further separating processes. Thus it is as an element though not as matter, the inseparable, the limit to diacosmical separation. From this point a new stage opens; the chemical synthesis begins to take place, the elements as indecomposable are united into compounds, so that decomposition, being halted, starts toward recomposition.

Thus Chemism, having gone back to solid, liquid, and gas, which were found already or were taken for granted in the first or immediate stage of the Diacosmos, has elementalized them into their original components, and then has proceeded to reconstitute these components into new solids, liquids, and gases, which are now of its own make. So we behold in this field a perpetual reconstruction of the material forms already constructed; the made world is always being re-made chemically as well as otherwise, the physical constitution of existence moves in an everlasting cycle of reconstitution. Nature, in order to be at all, can never cease turning back upon itself and making itself over; the Diacosmos, which is but a stage of total Nature, keeps rehabilitating itself through Chemism. The universe, ever getting older, is at the same time ever being new-born—a reflection whereof we may witness in the chemical act, both as it is in itself, and as the completion or third stage of the

diacosmical circuit. So in Chemism we behold the Diacosmos returning to its starting-point and rounding itself out into its integral process as a whole.

Here rises the question about the method or means which Chemism employs for its work of decomposition. What does it bring to bear upon composite substances in order to reduce them to their elements? The general answer is energy, chemical energy, which is thus a kind of obscure power, to be drawn upon by the scientist in case of necessity. Energy is a good word and we use it, but the confession has to be made that all sorts of tricks are played with it in these days; it is invoked as a kind of occult formula or dark shadow of an explanation which does not explain. At any rate our preference is to say and to see that Chemism employs as its grand instrumentality the three Radiants just set forth—Heat, Light, and Electricity—whose character is so deeply separative, radiative, divisive, even self-divisive. We may call them. if we like, radiant energies. But the fact is, that they accompany all chemical action, seemingly are born of it, and are used by it for its least and its greatest disintegrations. In general the chemical laboratory of the Sun radiates the three Radiants as we have already noticed; in them separation itself is undulated through our planetary system into the interstellar spaces.

The conception has been already brought for-

ward that those three Radiants are originally but one from which they are differentiated or radiated. There is the single primordial Radiant, which we may deem the universal diacosmical Ray out of which spring Heat, Light and Electricity. All these produce chemical effects, as is well known. To be sure there is a special ray called the actinic, which works chemically. But the entire scale of rays, which scientists have conceived as a kind of key-board (see preceding p. 448), has seemingly a graded chemical power, which starts with assailing and then destroying cohesion, from which it rises to disintegrating the molecule and even to dissociating the atom, as the word now goes. The radiation of the Radiants is the deepest act of diacosmical separation, and this is what Chemism employs in decomposing the material universe and sometimes in recomposing it, as we see for instance in the case of oxygen and hydrogen. We have already treated of these Radiants in their own right, as phenomena of Nature with their own laws and processes. Their character was observed to be deeply separative both in itself and in its action upon bodies. But now we behold them to be a part of a greater process; their place and purpose are seen to be the reduction of the physical All to its elements which are to have a fresh recombination. Thus the Radiants have their part in the larger plan of rebuilding the world, of transforming it anew, the transformer being

Chemism, under whose direction or end they do their work.

Using the terms which we have employed for this purpose, we may say that the chemical Diacosmos (third stage) returns to the molecular Diacosmos (first stage) in the forms of solid, liquid and gas, disintegrates them into their elements by means of the radiant Diacosmos (second stage) and then redintegrates them into new forms of themselves, which, however, have again to be thrown into the furnace. Such is the diacosmical round perpetually going on in Nature, which in the present stage we observe to be separative, radiative, or radio-active throughout, dividing itself till it reaches the limit of division in the element or the indivisible unit, at which the separative Diacosmos is brought to a halt. Moreover the idea of redintegration and restoration after dissolution and destruction implies a new order of Nature different from the diacosmical. Still these new substances, continually thrown up by the chemical process, are at once flung back into the diacosmical melting-pot, and sooner or later are dissolved into their elements again. Thus the elemental unit, unassailable we may conceive it for the present, is whelmed anew into the whirling abyss whence it sprang. It cannot control the chemical process but is controlled by the same at last, and is drawn again into the diacosmical maelstrom. The problem then comes up:

What can control this negative power devouring (like old Saturn) its children, the elements? At present only this outlook can be stated: the master of the foregoing chemical process will appear when we come to Life (or the Biocosmos). At present we need merely note the final self-undoing act of Chemism: it disintegrates what it has integrated, and thus nullifies itself. In this final act also we may glimpse the negative outcome of the whole Diacosmos in its own self-negation. In general as separative it must separate from itself, or perchance separate from its own separation—in which act peers forth again the function which has been called dialectical, and which lurks and works in all Nature.

We return to make a fresh grapple with the 80 chemical elements (more or less), and to press them with an unfailing interrogation: Have they any unity? In this age of evolution there is a loud demand to develop them from one original element, if possible. Just as the Radiants are deemed to differentiate themselves out of one universal creative Ray, so the chemical elements, irreducible here on our earth by any known process, must be reduced to their original unit by the mightier energies of the stars. Our Sun shows already a multiplicity of metals in the spectroscope; evidently its present heat is not great enough to fuse the recalcitrant individuals of Chemism back into their primordial source. But

there are stars which show a much greater thermal energy—those in the Constellation Argo, for instance, as reported by Lockyer—and which are supposed to manifest now what the heat of our Sun was many millions of years ago, before it had cooled down to its present temperature and produced the existing diversity of elements. According to this view, the star is a chemical laboratory which is evolving the elemental individuals, and which seems to be continually increasing the number of them down the scale of their descent through the stellar and planetary orders, till the known terrestrial 80 elements have been reached. It is generally thought that we have with us many others as yet unknown. One might calculate at the present rate of increase how many will be found in the text-books on chemistry of the year 2000 A. D. Indeed it is probable that new elements are continually being evolved or emanated, like helium and probably lead from radium. The next leap of thought is that man is on the way to make his own element, not merely to transmute one metal into another—which was the dream of the alchemists long ago, but which has surprisingly started up afresh in the minds of some recent scientists.

Probably the best claim for the place of the first element can be made for hydrogen, or protohydrogen as it is often called from its spectroscopic appearance in the hottest stars. Moreover this is

the lightest of the elements, and evidently stands nearer than any other substance to the imponderable gravitationless Ether which is doubtless the coming source of the elements including hydrogen. At any rate the electronic theory of Matter as it is called, cannot stop long at its present landing-place, but must push forth into the deeper ultimate, yea into the deepest and the universal one, which has been already designated elsewhere as the etherion.

The problem of the unification of the chemical elements, of tracing them to a common origin still awaits experimental solution. In some respects it may be deemed the scientific goal of chemistry. Ever since Prout gave forth that seed-thought (see preceding p. 282) that hydrogen was the original element from which the other elements were derived, the idea of their evolution has never been lost, though many famous chemists have spurned it, saying among other things that Prout was not a professional chemist but only a physician. Still the egg was laid in that evolutionary nineteenth century, and there can be no peace till the chick be hatched. At present the favorite original unit of the physical All is the electron (spelled *electrion,* we notice, by Lord Kelvin). It is difficult to see how the separative movement can be halted just at this point, even by the generalissimos of science; for it is not pretended that there is any direct experimental proof

of the electron. Indeed this very distinctly calls for another step forward—a step to be taken out of itself—which call seems to have been heard in the distance by the Russian chemist Mendelejeff.

Hitherto we have regarded chiefly the chemical element; now we may take a glance at the atom which has played and still plays a great part in Chemism. The atom is properly conceived as the indivisible ultimate upon which all division of matter finally strikes; the chemical element is supposed to be made up of atoms. So it seems that this element is not quantitatively the chemical unit, but is such qualitatively. We conceive the chemical element to be homogeneous and indecomposable, but divisible, while the atom is homogeneous but indivisible. On the other hand the molecule as made up of two or more elements, is heterogeneous and decomposable, as well as divisible. Thus we may conceive the atomic principle to return to the molecule, the beginning of the Diacosmos, and to separate it (the molecule) into its constituent indecomposable elements, and then to separate the latter into their constituent indivisible atoms. At this point division is or was supposed to be stopped, and the movement of diacosmical separation brought to a conclusion. But this final atom we shall find stoutly assailed in recent chemistry and impugned both as to its indivisibility and its homogeneity.

It may well be asked what forced the atom to be

taken up into chemical science. The simple elements as ultimate had been discovered; was there any reason why the atom should be resurrected and injected into or perchance under them as their deeper principle? The reason lay in another important discovery: this was that the chemical elements were combined in fixed and invariable proportions by weight. A constant quantity of an element was taken into the combination; if there was an excess, a residue would be found. Evidently Chemism showed the tendency to quantify itself; one element in uniting with another element would seem to weigh it off, saying just so much for me and no more. The *quantum* of each of the combining elements now comes decidedly into the foreground; each measures each for its component and takes its own measure; then they unite chemically, making a new substance often different in property from either component. But at what point does such a combination take place? If the compound be divided mechanically into the smallest particles, each particle will still show the compound. Naturally the conception arose that the combining particle of the chemical element lay beyond division, was just the indivisible, the atom.

Of course this atom was a speculative entity, made by mind but projected into matter to explain the facts of Chemism. The atomic theory affirms that the chemical compound is formed of

atoms of which the simple homogeneous element is composed, and which are constant in weight. Thus each of the eighty elements is made up of its own atoms, of which atoms accordingly there are eighty different kinds in Nature. When more elements are discovered there will be more kinds of atoms known to us. The fact of multiple proportions of the same two elements, when they form together several compounds should be here noticed; the different combining quantities of the same element are represented by whole numbers or are multiples of the first. This fact again shows Chemism carefully measuring by weight the constituents of its compounds, and rejecting the too much or too little. Chemism is a goddess holding a pair of scales (but not blinded like Astraea).

The chemical element, accordingly, in its decomposition and recomposition calls for accurate measurement; it is in its way mathematical, and has in its innermost character Measure, which we have found in all Nature along with Motion and Matter (see preceding page 43, etc.). Moreover, the ultimate unit of the element, namely, its atom, is what has to be measured, hence this measurement is often called the atomic weight. Moreover, at this point a further problem comes up: if the atom of every element is to be measured by weight, what is to be taken as the standard or unit of measure? Hydrogen is the lightest element, so it is set

down as one (or the unit of measure) in the ordinary table of atomic weights; to an atom of hydrogen all other atoms of the chemical elements are compared in weight. Such is the important fact of chemical Measure in which we see again Nature measuring herself in her way. But man has to re-measure her, and translate such measurements into his own mathematical forms. Of course some individual hero of science hears the call to this field, and does the epoch-making work. In the present sphere we have to celebrate the name of Dalton as the founder of the atomic theory of Chemism and so the chief measurer of its phenomena. He was hardly more than an amateur chemist, still did the greatest chemical deed in the history of the science. He has no small claim to be called the Newton of chemistry, though he was as little a trained mathematician as a trained chemist.

John Dalton (1766-1844) was born in England of Quaker parentage, and clung to the simple life and faith of his co-religionists throughout his career, wearing their costume and employing their dialect (thee and thou) even among the well-groomed, high-toned scientists of the world, whom he sometimes saw at London. He was properly a rural schoolmaster addicted to tireless interrogations of Nature in his modest way; among other records, his biographer reports more than 200,000 meteorological observations taken by Dalton dur-

ing his life, seemingly for his own private satisfaction. His range was not large, he had few books, but one of them was Newton, who was evidently his scientific bible. Through Newton he learned of the atom, which, however, Newton could not manage, as it lay outside of the Newtonian (cosmical) field. Interesting is the citation which Dalton makes from Newton: "God made solid impenetrable particles" as the ultimates of matter—unchangeable, indestructible, indivisible. This was the thought which sank deep into Dalton showing that his mind was essentially diacosmical, and therein very different from Newton's bent (in spite of the latter's optical and other physical experiments). We get the impression from converse with Dalton's life and works that his very Self was atomic by nature, and that he simply discovered or rather explained himself in explaining the atom. This, by the way, is pretty much the case with all great discoverers: they discover themselves in their discoveries, though the latter be also objective—a stage of Nature, a part of the Universe. John Dalton's soul was a kind of universal atom, self-seeing of course, and hence it saw itself with such clearness in the chemical soul of Nature. Unconsciously his God was atomic, even if he went all his days to Quaker meeting and communed silently with the spirit among drab-suited, humble-hatted Friends. Moreover the age was getting atomic and its science

too; already the fact has been noted that the eighteenth century had a chemical trend, in contrast with the preceding seventeenth, which was mechanical (Newtonian) and also in contrast with the succeeding nineteenth, which was biological and evolutionary (Darwinian). But there is a streak of the world's comedy in the fact that the Spirit of the Age with a sort of ironical scoff, should choose for its supreme scientific expression a rural schoolmaster of Quakerdom instead of the high-placed scientists of London and Paris, and instead of the well-trained professors of chemistry at the University. Dalton was for a while teacher in a small college at Manchester, but gave it up, and then (after 1799) made his living by taking private pupils.

Historically considered, the atom is a striking return of modern science to old Greece for getting a basic thought. Ancient Democritus must have had the atomic God within him even more strongly and more consciously than Dalton, since with the former atomism was a philosophical principle of the universe, while with the latter it was a concept for explaining the phenomena of Chemism. The doctrine of Democritus (or perchance of his teacher Leucippus) sprang from the four elements of the previous Greek philosophers, which, however, were not our modern chemical elements, but those of immediate Nature. Still we may see in ancient as well as in recent atomism the same

fundamental object: the search for the unification of the manifold ultimates of the physical world, called in both cases the elements. The indivisible, indecomposable unit is posited, the atom, from which all separation and change are excluded so that it can be the source, in its various combinations, of all separation and change. Democritus atomized Nature by thought not by a chemical process; he represents the idea of the atom rising long in advance of its realization; the old Greek is therefore its prophet who has to wait more than two thousand years for the fulfilment of his oracle.

The atom being accepted, the difficulty of it begins. It is declared to be the ultimate unit of the physical All, yet at once it shows itself to be dual. It may be called the composite of thought and matter, being a thought which is posited as material. Science in the atom is not to be sensed, and drops direct experiment as its test. We may designate the atom as ideo-physical, a material immateriality. Thus the atom is a peculiar compound, but not in strictness chemically compounded; rather is it the one underlying compound of all Chemism. Its object is to unify the vast diversity of Nature in a single ultimate individual, simple, homogeneous, which, however, turns out double and heterogeneous. Thus it contains by its very origin an abundance of explosive material. Still in a sense the atom is typical of all Nature, which through and through must be

regarded as a union of Mind and Matter. The inherent twofoldness (duplicity) of Nature has already been noticed, with her subtle ever-changeful dialectic. In this respect the atom is truly natural; it may be taken as the type of physical science which down to its very bottom shows the dualism projected into the atom.

Another difficulty about the atom is more famous, but not so deep. It is declared to be indivisible, and yet is an extended piece of matter. This contradiction has gotten a great name through Kant, whose second antinomy is based upon it. Here again the previous dualism makes its appearance. The thought side of the atom is its indivisibility, while its material side is its divisibility. Those two sides, we repeat, belong not merely to the atom but to all Nature. Still the original purpose of the atom was to find the physical unit from which every division should be eliminated and made extra-atomic. But we see it to have the deepest division within it, verily the ultimate division of Nature herself. The indivisible atom is, accordingly, just the absolutely divided, being the very type of universal separation which must be, accordingly, intra-atomic.

It is no wonder, then, that the most recent theoretic chemistry is furiously attacking the atom, yea is tearing it to tatters. The earlier chemical science sought to reduce the world's compounds to their irreducible elements; the next

stage of Chemism (say the Daltonian) sought to reduce still further these elements to their indivisible atoms; but now the third stage has dawned which is proceeding desperately to atomize the atom and thus to serve up to the same its own inherent character, by which all matter has been so transcendently and even supersensibly divided. The atom (or its supporters) after making its fine division tried to call a halt to any further work like its own, saying: "I am the indivisible and the grand finality." Thus we may conceive it speaking and trying to stop the furious chemical dissolution of this solid universe. But it has been unable to put a limit upon Chemism and upon the madly separative energy of the Diacosmos. Consequently we now hear with a loud din the atom exploded, disintegrated, dissociated. All this is heralded not merely as the new chemistry but as the new science; yea, the science of all sciences is announced to have at last made therein its true appearance upon our planet.

All this sounds pretentious enough, if not a little terrible and anarchic; surely our ever-separating Diacosmos seems to be going to pieces in this its final act through its own self-undoing dialectic. But now comes a new turn just in this field: the atom though divided and disintegrated is put together again into a system. An atom of hydrogen, for instance, is declared to contain a thousand electrons (or electric corpuscles) whirling around

within its sphere in a certain order. Sir Oliver Lodge for illustration calls up the image of a church in which a thousand grains of sand are revolving and rotating with an enormous velocity—blasting, bombarding, often colliding. The unit of Matter is no longer the atom, but the electron, which the scientist now employs to explain solids, liquids, and gases, the first shapes of the Diacosmos, under the general theorem that Matter is electricity and nothing else. Still further, the chemist introduces the electron to explain the atomic weights of the chemical elements, declaring that the atom of oxygen contains 16,000 electrons, that of mercury 200,000, if the atom of hydrogen has 1,000. By the same means other chemical phenomena are interpreted electrically, such as valency, the periodic law, and chemical action. This is, briefly stated, the electronic theory of Matter, at present culminant, we might almost say raging in science. Really, however, it does away with Matter (or makes the attempt), as the electron is supposed to have no material substrate, but to be purely an electric discharge—not electrified Matter but the original electric monad of the physical universe. Thus the deepest unity of Chemism and also of the Diacosmos is claimed to be reached at last: but we shall find that the electron too does not escape the dualism which has already rent asunder the element and the atom.

Not the least significant phase in the develop-

ment of this electronic theory is the fact that the atom becomes systemic, a reflection as it were of the solar system. The electrons are declared to be moving inside the atomic boundary, rotating on their own axes and seemingly also revolving in their orbits like miniature planets, which are not atomic but intra-atomic—thousands of them perchance moving in the limits of a single atom. And these atoms are already pretty small, if it takes, as the calculation runs, millions of millions to fill a square inch. But the interest is to see the macrocosm getting truly microcosmic in this conception, or as we may state it in our special terms, to see the Cosmos mirroring itself everywhere, even in the smallest conceivable particle of the Diacosmos, which is now supposed to have not simply an atomic order, but an intra-atomic planetary order of electrons. Another striking fact in this connection is that Mathematics have entered the atom once imagined to be impenetrable, and have calculated the motions of these electrons, as the cosmical motions of the planets and stars have been measured. Prof. J. J. Thomson is the mathematical scientist who has done the main work in this field, though the start is traced back to Clerk-Maxwell. The movement of the 1,000 electrons of the hydrogen atom become somewhat complicated; but what about the order of the 225,000 declared to be in an atom of radium, whose atomic weight is set down at 225 (in the international

table)? The stellar motions of the Pancosmos furnish the only parallel. If we can see on a clear night merely 3 to 4,000 stars, we may imagine (if we can) seventy times as many electric light-points to be flashing and whirling around in an atom of radium after some principle of order.

Undoubtedly all this is speculation, yea speculation of speculation, for the atom is already speculation, being not amenable to sensuous experiment. So the electron speculatively puts a new speculation into what was already speculative. Such is the last act of to-day's Natural Science, in its flight or return to Metaphysics, notwithstanding its protests, denials and even execrations. At any rate we behold the atom made systemic by the scientific consciousness of the time, though conservative scientists are still shaking their heads at the unparalleled audacity. The systemic atom of the Diacosmos thus has its counterpart in the systemic Cosmos—the infinitely large reflecting itself physically in the infinitely small. Indeed we hear of systems of systems, which are supposed to lurk and move in the various diacosmical atoms. The high atomic weights of certain elements, like mercury (200), or lead (206+), or radium (225), seem to compel systems within systems of electrons, all of them inside the one invisible atom. Again the comparison with the cosmical order comes up in the mind. We think of the Heliosphere with its planets and their satelites whirling axially and or-

bitally through space; yea we are carried up into the Galactosphere, even into the Cosmosphere with its stellar systems of systems, which the scientific mind of the present seems to be transplanting and after its manner idealizing in the systemic atom with a manifold arrangement of rotating electrons. Thus does the vast outer organism of the Cosmos interiorize and concentrate itself in the minute electronic organism of the Diacosmos.

Such is, in general, the electronic theory of Matter, or rather of the physical universe, being emphatically the storm-center of the scientific thought of the present moment. Inevitably there rises the problem of the validity of such a theory and also of its permanence. Is the electron likely to go the way of the element and of the atom? Has it too that subtle dualism of Nature which in the end will disrupt it and explode it like a charge of dynamite? Such seems to be its character. First of all, the electron, as constituted purely of electricity, participates merely in one of the Radiants, or in one of the many modes of Motion. Heat and Light are also Radiants in their own right, and each of them can furnish the ultimate unit as well as Electricity. There is no reason why we should not have a *thermion* along with the statement that Matter is Heat and nothing but Heat, as well as an electron. Or perchance a *photion* might be preferred, a radiation of a light-point, as the basic principle. Also the common ray out of which the

three Radiants are supposed to proceed might be taken as the true original of our material world. But they all have one defect: they are special modes of Motion, or forms of energy; none of them can lay any claim to be the universal element or the element of the universe as physical. What then is such? Already such an element has been pointed out in the Ether, whose ultimate component particle we have called the Etherion which is composed of the primal elemental constituents of the Cosmos, Motion and Matter (see preceding p. 419).

Moreover we read that the electrons of the atom —thousands of them whirling in it—are charged with negative electricity, while the periphery or sphere of the atom which contains them is of positive electricity, of which any further knowledge is specially disclaimed. The assumption seems arbitrary, but with it has risen the old dualism in a new form. The two electricities, positive and negative, each opposite to the other, have been injected into this electronic atom, and are certain to tear it asunder by their antagonistic energies, repeating doubtless with greater force what we have already seen in their antecedents. This last tragic scene may not yet have taken place, but the outlook for it must be deemed promising.

Noteworthy is the fact that Chemistry is getting out of itself, out of its elements and even out of its atoms, and is going back to the previous

stage of the Radiants for its elementa. unit. It has started with Electricity (electron) and may yet pass back to Light (photion), and even to Heat (thermion). These Radiants are its energies, its diacosmical instrumentalities, which it employs for decomposition and recomposition. Heat, Light and Electricity both beget and are begotten by chemical action. Still they are but special forms of a universal power which is the final object of search; they are particular modes of Motion, not Motion itself in its ultimate reality; hence they can be regarded as only temporary landing-places for the scientific spirit in its evolution toward the universal element. In spite of the asserted oneness of Nature in and through the electron, twoness has crept into it primarily by means of the two electricities; but we should also see that Matter, after being cast out, is really hypostasized in the atomic envelope or sphere containing the electrons. It is self-delusion to call this envelope positive electricity, and then disclaim all knowledge of its character. The fact is that both Matter and Motion, upon a close analysis, will be found underlying the electron, which thus pushes forward out of itself into a higher principle which we may already glimpse as the Etherion.

Evidently Chemism is forging backward (or forward if you prefer) to the universal cosmic protoplasm which has been named Ether, and which is not Motion nor Matter as separate, but the two in

their earliest state before separation. Already we have treated Motion and Matter as stages of the elemental Cosmos (see preceding pp. 39-41); at present we behold them in their primordial real aspect, in which the chemical element of the Diacosmos is at least on the search for its origin Thus again the last goes back and seeks to interlink with the first. That is, our Diacosmos not only returns upon itself and forms its own round within itself (as already pointed out) but returns to the very start of the Cosmos. The Etherion hints, of course speculatively, of the chemical atom of any one of the separate elements traveling backward till it comes to the universal element from which they all sprang and in which they are still coming and going, arising and departing.

Here we may speak of another cycle, or rather series of cycles in Chemism which has been recently discovered and formulated, especially by the famous Russian chemist Mendelejeff. The 80 elements, arranged in the order of their atomic weights (from hydrogen = 1, till uranium = 240) are found to move in self-returning cycles of eight elements from the lightest to the heaviest, with recurring properties. These cycles are known as groups of which twelve (called series) have been set down in a table—vacant spaces being left for elements as yet undiscovered but required for completing the given cycle. It is a suggestive fact

that some of these vacant spaces in Mendelejeff's table have been filled quite recently by new elements whose discovery was prophesied if not directly brought about by this law of the elemental round in Chemism. The names of these three new elements are scandium, gallium, and germanium; they were discovered respectively by a Swedish, a French, and a German chemist, each of whom patriotically baptized his child with the name of his fatherland. (Americanium is yet absent from the list.) The whole is usually known as the Periodic Law or System of Chemical Elements; but it is best conceived from its cyclical character, being a progression of the cycles of the chemical elements, whose properties keep recurring in eights (called octaves by Newlands, the first observer of this phenomenon). Thus the properties of the elements are always returning and rounding themselves out in rings or perchance spirals which may be counted to the apex of a supposed cone. (The best way to grasp this subject is by means of the tables in the latest text-books of chemistry.)

It is, therefore, the atomic weight which gives to the special chemical element its place in the totality of elements. This means its distinctive property, its character, its individuality. Moreover these 80 elemental characters do not evolve on a straight line but keep recurring in the aforesaid octaves quite regularly, though there are some hitches. Still further, the atomic weight as

the salient character in this periodic order, carries us back to gravitation, according to which each element gets its quality and rank. It is not merely heavy like so much cosmical matter, but its relative weight marks, if it does not produce character, individuality. So the element also gravitates in its own way, and overcomes its separative diacosmical nature in the unity of terrestrial attraction. Very suggestive is this reappearance of the determining power of gravitation, whose quantity measures elemental quality, and indeed the whole cyclical movement of the elements. We are reminded of the Fluids, which in spite of their diacosmical opposition at last yield to the might of gravitation (if the Ether be excepted).

Historically this fact of elemental periodicity has been known in some shape for a good while, and has gone through its own course of evolution. It distinctly appears (by threes) in the triads of Dobereiner. It was suggested far more completely in the elemental octaves of Newlands, in which the analogy to the recurrent octaves of the musical scale is very striking. The German chemist Lothar Meyer wrought out the same general scheme, but its priority as well as its completest form are assigned to Mendelejeff. So we have to conceive a whirl of elemental properties evolving around and forward according to their atomic weights. These periodic cycles of the chemical elements have been tested by experiment and are

generally accepted; yea some periods within periods have been indicated, as if here too the cycle was made up of still finer cycles. But the grand speculative outreach of Mendelejeff has been too audacious for the chemical mind: the 80 elements enringned in eight cyclical groups he carries back to a single original element, the Ether, which he thinks has nearly one-millionth of the atomic weight of hydrogen, the lightest of the elements, and the basis of their comparative weights. Accordingly the great Russian chemist puts Ether into his table of chemical elements, placing it first in the so-called zero group (with helium, neon, argon, etc.). But Ether as the universal substance doubtless transcends Chemism, which is particular in action and deals with particulars. Still it is very suggestive that this last science of the Diacosmos in all its separation is reaching out for the ultimate unit of chemistry and therein of all Nature. Still it will hardly do to subsume Ether under Chemism, making the same a chemical element, even the original one; it goes back for its composition to a source more ultimate, to Motion and Matter.

But the most interesting fact of recent chemistry is that within the last few years a new element has been brought to light which can lay some claim to chemical universality. That is, a universal element within the sphere of Chemism has been found in radium, according to the view of

certain scientists. As far as known it seems to be a speck of pure radiation, for it has never been isolated from its material compound or envelop, which is usually barium. All attempts to get radium in itself have failed. Still its spectrum and its atomic weight, and hence its cyclical or periodic position, have been determined. As yet, therefore, radium will not give up its composite dualism to any torture of experimentation. Its supreme characteristic is to be radiative, or, as the books say, radio-active; it perpetually separates itself within and sweeps outward in self-luminous manifestation. It may pass for a piece of the sun left behind in our earth from the primal planetary separation, a small granular relic of the Heliosphere. To push the idea beyond and beyond, radium may be identified with primeval starlight, and may yet tell us somewhat of the composition and nature of the stellar universe, as well as of our own solar luminary. Little starry bits, then, have been strewn over our globe possibly from the old æons of the Cosmosphere, and we are just beginning to pick them up.

As in case of the sun and stars the problem comes up about the persistence of radium. How long will it last? Does it, too, die? Here also the radiative energy lessens and possibly expires in time. The life of radium is set down at two thousand years, when its enemy, whatever that be, overcomes it and subordinates it to a new control.

On the other hand, uranium, likewise a radio-active element, but far less energetic than radium, is computed to last a hundred million of years, when it also must pass through some kind of grave like its stellar counterparts, whose life, death and resurrection have been already forecast (see preceding p. 278, etc.). So the inference is drawn that these radio-active elements are finite and a part of a greater process than themselves; mortal, transitory, they confess to a stronger power, and even call for it, which is immortal, omnipresent, endowed with universality, and which physically can only be the Ether, the universal Fluid already described, having its own particle, molecule, atom, (yet different from all these), namely the Etherion. Radiation, it would seem, perishes if kept asunder from its counterpart or antitype which is attraction; or, more generally stated, all forms of degravitation are destined to vanish unless interlinked and complemented by gravitation. We note again that the radiative, separative Diacosmos would inherently separate from itself and go to pieces through its own dialectic unless supported by the unitary Cosmos to which it is always going back for its substrate. Thus the two belong together and constitute stages of that ultimate process of Nature upon which we always impinge on coming to the bottom.

Radium shares its special radio-activity with several other allied elements—uranium, thorium,

polonium, actinium (to these are sometimes added emanium, radio-tellurium and even lead in a certain condition). Thus we begin to think of an original radio-active substance of which these may all be derivations or emanations. Indeed several of them have their own peculiar emanations, notably radium, as if they might be simply re-enacting in a weaker way their own origin. Still further, they have rays of essentially distinct properties, and therein differ from ordinary light, whose reflection, refraction and polarization they do not possess. Radium has an alpha-ray electrically positive, of considerable velocity, but very slightly penetrating. The beta-ray on the other hand is negatively electrical, very swift, and moderately penetrating, while the gamma-ray is enormously penetrating, since it can pass through solid iron a foot thick with its light and affect a photographic plate. Some scientists identify it with the *x*-rayof Roentgen, to which it is similar, yet also different. The important point here is to observe a wholly new differentiation of the Radiant, especially of Light (though an invisible ray is also noted); there would seem to be a deeper sort of spectrum which divides the universal Ray not merely into colors, or even into visible and invisible portions, but into entirely new forms of radiation possessing strangely unusual powers. As we sought to carry back the three separate Radiants—Heat, Light and Electricity—to one common Radiant, so now we are

driven to think of a radiative energy still more universal, which differentiates itself not simply quantitatively (like the ordinary spectrum) but also qualitatively, raying not only the one scale (or key-board) of Radiants, but many diverse scales.

The relation of radium to the three Radiants of the Diacosmos is certainly very intimate—so intimate that it has been sometimes thought to be their source. Its discoverers, Madam and M. Curie, found that its heating power was so great that it raised the temperature around it three degrees (F) nearly; thus each atom of it is a little white-hot furnace; every hour it throws out Heat enough "to raise its own weight of water from the freezing-point to the boiling-point." Here would seem to lie the great future reservoir of energy when it once gets tapped by an adequate machine. But still more striking is the fact that it does not burn up, having the power to furnish indefinitely its own fuel, seemingly during its life of thousands of years. Power for nothing lies around us, free as water or air, though it has somehow to be put into harness. Naturally the thought comes up that the sun and stars must be chiefly of radium, which thus drives the physical universe. At the same time it furnishes Light, the second Radiant, and also Electricity, the third Radiant. In this case we begin to glimpse the elemental unit which is the source of Radiantism in Heat, Light and Elec-

tricity. Possibly, too, it may be the parent of all the chemical elements, generating them in time, as it does helium and apparently lead. Its chief competitor for the honor of such a line of descendents has been hydrogen or proto-hydrogen, which is so often found in close proximity with helium in the spectrum of the hottest stars. The thought lies near that both these seeming twins spring of one parent.

The discovery that radium, one of the heaviest elements, evolves or emanates helium, one of the lightest, a gas of the *argon* group with its own spectrum, has given a strong shock to the whole chemical world and turned it back to its origin in alchemy, which sought so desperately the transmutation of metals. (See the book by Prof. Duncan of Kansas, entitled *The New Knowledge*, for many evidences of this shock, even the style being somewhat earthquaky.) Moreover it is conjectured that radium itself is an evolution from uranium, as well as its allied radio-active group. Our common lead is strongly suspected of being derived from uranium, which is deemed the primordial radio-active element. Another very suggestive fact about radium is that its emanative activity moves in a cycle; if it radiates a part of its power and thus loses the same, it will in time regain what it has lost. The radio-active energy which it may throw out in an hour, will be restored in some days. This would seem to indicate that all

radio-activity moves in cycles small and great, through brief moments and vast æons. The cycle of uranium, embracing doubtless its life (a hundred million of years), death and resurrection, cannot be calculated at present, but each little emanation seems to have a corresponding round, which we may possibly bring into relation with the electrical circuit.

The account of the pursuit of radium, which had long been glimpsed, has laid hold of the imagination of the public, including both sexes, since a female investigator steps into the forefront of scientific discovery, seemingly for the first time in history. The center of interest is Madam Curie, a Polish lady married to a French scientist at Paris. It is noteworthy, however, that the important nations of Europe are represented in the various stages which led up to the culminating deed; English, Dutch, German (Roentgen rays), Russian (Niewenglowski rays) participated in the evolution of radium. But the immediate predecessor was a Frenchman, M. Henri Becquerel, who discovered that a uranium salt would emit rays which affected a photographic plate through black paper, and also through thin plates of metal and other substances. Here, then, was the radioactive principle manifested with its special penetrating power. But the final step was yet to be taken by Madam Sklodowski Curie and her husband, M. Pierre Curie. They hit upon the lucky

idea of going back to pitchblende, the parent mineral of uranium, some specimens of which they found to possess a radio-activity several times greater than that of the metal uranium taken by itself. At once they started in search of this new substance, and found it, which they very happily called radium. Indeed this name must be deemed an inspiration of far-reaching import since it connects this last chemical element not only with the diacosmical Radiants, but with all radiation, including doubtless the original radial motion of the Cosmos. In this thought radium, so far the final result of Chemism, or perchance the universal chemical element, turns us back again to the cosmical beginning.

The intense popular interest of our time in radium indicates that we see in the same some striking counterpart or fresh revelation of ourselves, perchance the chemical symbol of our consciousness. Its self-separative act, or more specially its self-radiative energy suggests our own conscious activity, which likewise divides within and rays itself out into object, but with that self-return which completes the process of the Ego. Such a self-return belongs not to radium, yet is faintly suggested in the fact already noted that it slowly recovers what it has lost by emanation. Still it never regains wholly its own, for it vanishes after thousands of years (two or three). Thus our separative Diacosmos has evolved

a piece of matter which separates itself and continues doing so, becoming purely radiative almost; having still a shred of gravitative matter to which it clings and from which it seemingly cannot be altogether divorced. Thus radium in itself is as yet an idea which we have by our own mind to abstract out of its material wrappage, somewhat as ancient Plato bids us do with his supersensible ideas. Strange realization of old Greece again! The atom of Democrites we have already seen coming back in Chemism, and now its hostile counterpart in antiquity, the Platonic Idea, flits spectrally before us in this new element. Radio-activity is its specially designated property, but this term we have applied not only to the Radiants but to the whole Diacosmos; and now we begin to hear that all Matter is radio-active, more or less. The diacosmical power of radiation after having exerted itself in the Fluids and in the Radiants as a secret energy, has evolved into a chemical element, manifesting itself in its own right and in its own form (nearly but not quite). The gift of impartation it has also, making other substances in its field radio-active, and even the experimenter dealing with it (as M. Curie found to his cost).

The cause of radio-activity has been referred to the disintegration of the atom, and it is at this point that the electronic theory of matter becomes connected with the present subject. On the other

hand the cause of the disintegration of the atom has been referred to radio-activity. Thus the reasoning is at least in a circle; and in spite of the conjectures and even mathematical calculations of eminent scientists, nothing decisive can be reported in regard to this portion of the science. The dissolution of the atom into electrons, their movements in it, as well as their co-ordination into a system have been supposed to be largely the work of radio-activity. Here, however, we must wait for the future, with the outlook upon the electron passing into the etherion, which we have already sought to indicate as the universal element of all Nature—not simply a chemical element, but the element of all elements, which radium presupposes for its evolution. Indeed if radium emanates (evolves) helium, but is evolved in turn by uranium, it lies already midway in elemental evolution. Now all are asking, what emanates uranium?

Radio-activity, accordingly, in its general sense is the pervasive characteristic of the entire Diacosmos, which at last realizes it in a special form, embodying it in a particular chemical ultimate, radium. This we may deem for the present the conclusion of Chemism, whose function is to separate the physical universe into its elements. These it has continued to evolve till it has brought forth the radio-active, that is the self-radiative element, and thus has realized and

indeed materialized the regnant idea of the Diacosmos. And we may add that our age, which, as already noted, has a strong separative, diacosmical bent, has been brought to see a very significant phase of itself in this outcome, a sort of chemical adumtration of its own character.

Chemistry has become a great and complex science into whose details we cannot here enter. Only a very meager outline of its organization, as we conceive it, can be attempted.

I. Elemental Chemism. This would include a treatment of the chemical elements and their various processes, including the laws thereof. The ordinary text-books of chemistry are chiefly occupied in giving an account of these elements. (1) The compounds of the latter, with decomposition and recomposition form the most immediate chemical process, which is continually going on in the physical world. (2) From this process are drawn the principles or laws of chemical action, which finally reach the atom as the ultimate, and find expression in atomic weight, volume, valency, atomic linking, and specially periodicity. (3) The evolution of the chemical elements is the deep necessity of the science, which incessantly strives to bring its multiplicity into some sort of unity. The various struggles of the present time in this field have been already briefly noted.

II. Radiant Chemism. The three Radiants—Heat, Light and Electricity—have very pro-

nounced chemical relations which have been recently much studied. They have their own peculiar sphere with its principles, which has been already set forth; also chemistry has its peculiar sphere with its special principles. But now enters the fact that the three Radiants both produce and are produced by chemical action; Radiantism is both cause and effect of Chemism, whieh primarily uses it as an instrumentality of decomposition and recomposition, particularly employing Electricity in the Voltaic battery. From this point of view the science is divided into three parts: (1) *Thermo-chemistry*, dealing with Heat as a chemical agent which, on account of its separative power, disunites and then re-unites, overcoming its own separation; (2) *Photo-chemistry*, which deals with Light as a chemical agent, for instance in the manifold forms of photography, and as the revealer of chemical action, for instance in spectroscopy; (3) *Electro-chemistry*, which deals with Electricity both as producer and produced of Chemism. Still we are not to think that electrical action is chemical action, though both be inter-related and mutually generated; each of these processes has its distinctive place in the Diacosmos, which, however, associates them all while preserving their separate individuality. It is a chief difficulty with the electronic theory that it makes all Chemism simply the electric flash of an hypothetical electron. And in general Chemism is not Radiantism, nor mere

radio-activity, though standing in close relation to these phenomena. It is itself and nothing else, possessing its own individuality, which, however, is to be correlated with the other diacosmical individuals.

III. Atomic Chemism. We found the atom already in elemental Chemism (first stage), but to it we now must return with the last trend of chemistry which has picked up the old Daltonian atom (once regarded as ultimate) and is tearing it to pieces, analyzing the previous unit of analysis, dividing the formerly indivisible One, in fine, atomizing the atom itself and thus paying back to it its own in a kind of Satanic retribution. Yet the modern movement does not stop here, with such a purely negative result: it pushes on toward a re-constitution of the broken atom, into which it strives to put a system, to be sure not a chemical but an electric (or electronic) system. In this field of Atomic Chemism we may catch the following outline of a process : (1) the integral, transmitted atom, of which the chemical element was ultimately composed, is to be now decomposed or disintegrated; (2) the ions of Faraday doubtless begin the separative stage of the atom, which proceeds to the corpuscles (a somewhat uncertain word in this connection) and then reaches the electrons, thousands of which are moving separately in each elemental atom; (3) but these electrons are put into a system of revolving mo-

tions within the atom—which thereby becomes systemic, and is the present outcome of Chemism as a science.

Moreover this Systemic Atom is for us the conclusion of the Diacosmos, of which it is taken as the final principle or unit. In a similar manner we found the conclusion of the Cosmos to be a systemic unit, namely the Solar System, which may be conceived as an atom in the total stellar universe. These two atoms can again be called the macrocosmic and the microcosmic, or perchance better, the cosmical and diacosmical. The one is more associative, uniting through gravitation; the other is more dissociative, separating through radiation or radio-activity. At any rate we behold another form of that dualism which has been so often observed of Nature. Ultimately, however, they must be grasped as contained in a deeper unity, or rather as stages of the one total process of Nature, to which a third stage has to be added for completing the cycle of the physical All. That is, the Cosmos and the Diacosmos, as here conceived, call for their fulfilment in the Biocosmos, which as already designated (see preceding p. 21) is the order or science of Life in its widest aspect. But into that stage of Nature the present book cannot enter.